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ABSTRACT

A study evaluated the validity of the use of digital dexterity and reaction time as variables to predict students' gross typing speed. To gather data for the study, researchers tested approximately 120 students from three typing classes at Jefferson Community College in Louisiana and one typing class at the University of Louisville (Kentucky). In the first test, researchers used an electronic stopwatch, hand-held counter, and a digital computer to measure the digital dexterity of students entering the classes. The second test involved the use of a digital computer to measure the students' reaction time, ability to use their fingers independently, and speed at typing three random characters. Based on the results of the first test, it was concluded that little correlation exists between gross typing speed and digital dexterity. After correlating the results of the second test with students' gross typing speeds after the completion of a one-semester course, the researchers determined that reaction time and the ability to use fingers independently had moderate correlation coefficients with gross typing speed. The ability to type three random characters was, however, well correlated with typing speed. (MN)

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Technical Report 539

PREDICTION OF SUCCESS AT TYPING

Thomas G. Cleaver and Carol A. O'Connor
University of Louisville

BASIC RESEARCH

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This report details an experimental study of the prediction of gross typing speed. The study was conducted in two phases. In the first phase beginning typing students were given a battery of tests to measure digital dexterity, particularly of the index finger of the dominant hand. The test results were correlated with gross typing speed attained after a one-semester course. It was found that there was very little correlation between gross typing speed and digital dexterity.

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In the second phase of the study, beginning typing students were given a battery of computer-administered tests to measure reaction time, the ability to use the fingers independently, and the speed with which three random characters could be typed on a keyboard. The test results were correlated with gross typing speed after the completion of a one-semester course. It was found that reaction time and the ability to use the fingers independently had moderate correlation coefficients, but that the ability to type three random characters was well correlated with typing speed (R = .75). It was concluded that this last type of test, or some modification thereof, may be useful in screening typist trainees.

Technical Report 539

PREDICTION OF SUCCESS AT TYPING

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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) has performed basic research in the development of measures for identifying soldiers with good potential for developing speed and accuracy in typing as an important skill useful in many Army MOS categories. This report describes a two-phased research program to identify tests useful in screening typist trainees.

The technological base research described herein was conducted under Army Project 2Q161102B74F by the University of Louisville Foundation, Louisville, KY, under Contract No. MDA 903-79-C-0423.

JOSEPH ZEIDNER
Technical Director

PREDICTION OF SUCCESS AT TYPING

BRIEF

Requirement:

The requirement for this contract is as stated in the proposal "Prediction of Success at Typing by Use of a Simple Test of Digital Dexterity." This proposal states that preliminary research indicates a correlation between digital dexterity and performance of keyboard tasks. Experiments are described which measure digital dexterity by double taps on a key. It is proposed to measure the digital dexterity of beginning typists and then, upon completion of a typing course, to correlate their gross typing speeds with their digital dexterity test scores. After the results were analyzed, additional experiments were to be performed to refine and improve the experimental technique and to gather supporting data.

Procedure (first phase):

An electronic stopwatch, a manual hand-held counter, and a digital computer were used to administer tests of digital dexterity to students entering introductory typing courses. The double-tap experiment measured the time required for a subject to make two rapid taps with the index finger. The counter test measured the time required to advance a counter from zero to 50.

Findings (first phase):

Gross typing speed at the end of the typing courses was only slightly correlated with the dexterity test scores. The correlation coefficients were close to zero, and it was concluded that the digital dexterity tests were not sufficiently predictive to be useful. Therefore the experiments were redesigned to include measures of information processing ability.

Procedure (second phase):

A digital computer was used to administer three tests to students entering introductory typing courses. These tests consisted of measurement of reaction time, measurement of the ability to use the fingers independently, and measurement of the speed with which three random characters could be typed onto the computer keyboard.

Findings (second phase):

Upon completion of the typing course, gross typing speeds were measured and correlated with the three parts of the test. Correlation coefficients

of +.25, -.42, and -.75 were found for the reaction time test, the independent fingers test, and the three-character test, respectively. The excellent correlation of typing speed with the three-character test indicated that this test, or a modification thereof, could be used to screen typist trainees, but that refinement and simplification of the experimental technique would be required.

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PREDICTION OF SUCCESS AT TYPING

INTRODUCTION

Thousands of people every year begin typing training in high schools, colleges, trade schools, and military-operated schools. Rarely are the entrants screened in any way to determine their aptitude for typing. For the person who intends to be a casual typist, screening may be inappropriate; however, for the career-oriented individual, screening may be quite important. If screening reveals that an individual has limited aptitude for typing, then that person can be directed to a more appropriate career. This screening should be of benefit to the individual; if the individual is being trained at an employer's expense, the screening will also be of benefit to the employer.

Although there are many tests of clerical skills, most of them are intended as measures of current level of skill. Few purport to predict future aptitude after a training period is complete. However, some early studies sought to relate digital dexterity and mechanical aptitude to aptitude for keyboard tasks.

In 1927, T. W. MacQuarrie developed his Mechanical Aptitude Test.[1] Included in it were tests for tapping and dotting. His tapping test measured the speed with which a person could place three dots into each of a series of small circles; the dotting test required that the subject place a single dot in each of a number of unequally spaced circles. These tests were thought to be a measure of digital dexterity and eye-hand coordination. Other researchers attempted to use these tests as predictors for success in keyboard tasks.[2,3] The results indicated only a moderate amount of correlation with success in these tasks.

In 1951, Arline Blakemore conducted a series of tests on 16- to 19-year-old girls who were entering job training in a bank.[4] The typing production rate of the trainees (based on typing time, preparation time, and corrections) after 1 month of job training was compared with the results of five tests given at the time of employment. The best correlation coefficient (.62 ± .08) was obtained using the "Hay Number Perception Test," which takes about 12 minutes to administer. The girls in the study had all been previously trained as typists.

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[1] MacQuarrie, T. W. (1927). A mechanical ability test. J. Pers. Res., 5, 329-337.

[2] Gottsdanker, R. M. (1943). Measures of potentiality for machine calculation. J. Appl. Psychol., 27, 233-248.

[3] Barrett, D. M. (1946). Prediction of achievement in typewriting and stenography in a liberal arts college. J. Appl. Psychol., 30, 624-630.

[4] Blakemore, A. (1951). Reducing typing costs with aptitude tests. Personnel J., 30, 20-24.

The most ambitious and innovative attempt to evaluate typing aptitude was the work of Flanagan, Fivars, and Tuska in 1959.[5] They based their study on the hypotheses that skill at typing is related to

1. the ability to tap with one finger at a time by controlling each finger separately and independently, and

2. the ability to learn to respond with a particular finger on perceiving a number or letter.

In their test, adhesive-backed felt circles were attached to the end of each finger. Each pad was then moistened with a different color of ink. The "tapping test," as they have called it, consisted of nine separately timed sections. The first two were designed to test the first hypothesis; and the last seven, to test the second hypothesis. The subjects tapped their fingers onto each of 12 rows of circles on a page according to letters that had been assigned to the fingers.

Flanagan, Fivars, and Tuska compared typing speed in words per minute at the end of various typing courses to the scores achieved on tapping tests administered at the beginning of such courses, and they found predictive validity coefficients of approximately .50. They also found that scores on the tapping test were not well correlated with the level of experience of the subjects. This indicates that their tests are not biased in favor of experienced typists, and it also gives evidence that the dexterity required on the tapping test is not significantly improved by typing training. In still another test, they compared intelligence test scores to typing speed and found very little correlation.

Since publication of their paper, the authors have continued with their research and now publish a kit to administer the tapping test.[6] Businesses and others use the kits for screening purposes. The authors now distribute about 1,000 kits a year.[7]

Very little published research has been performed in this field since the work of Flanagan, Fivars, and Tuska. However, Cassel and Reier did compare typing speed tests to scores on the General Aptitude Test Battery (GATB).[8] They found that by using multiple regression they could obtain a correlation coefficient of .72.

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[5] Flanagan, J. C., Fivars, G., & Tuska, S. A. (1959). Predicting success in typing and keyboard operations. Pers. and Guid. J., 37, 5, 353-357.

[6] Flanagan, J. (1963). Manual for the Tapping Test. Pittsburgh: Psychometrics Techniques Associates.

[7] Fivars, G. Personal communication.

[8] Cassel, R. N., & Reier, G. W. (1971). Comparative analysis of concurrent and predictive validity for the GATB Clerical Aptitude Test Battery. J. Psych., 79, 135-140.

Although the tapping test may be useful as a predictor of success at typing, it is somewhat undesirable as a mass screening test because it is time-consuming and requires special materials (felt pads and colored inks). Also, the test is closely tied to eye-hand coordination, i.e., subjects must look at the paper in order to position their fingers properly. Experienced typists do not look at their fingers as they type; therefore, eye-hand coordination tests seem to be inappropriate.

In preliminary research, the author tested the speed of a number of subjects in the task of making two quick taps with the index finger on an on/off button of an electronic timer. The timer displayed the elapsed time between taps, which varied among subjects from 0.07 seconds to 0.16 seconds. The speed of tapping seemed to be related to keyboard and musical instrument skills (anecdotal). Since the index finger is the most used digit, it is reasonable to presume that in adults this digit is extremely well trained and that, in fact, it is trained to such an extent that performance in this simple tapping task cannot be improved significantly by practice. Indeed, it was also found in the preliminary tests that no significant or repeatable improvement in time could be achieved through practice. It was therefore tentatively concluded that the speed of tapping in this task was relatively untrainable and that it was a measure of inherent, perhaps genetically determined, index finger dexterity, and perhaps of digital dexterity in general.

Phase I of the research described herein is based on the hypothesis that the speed with which adults can tap their fingers twice in succession is a measure of inherent digital dexterity and that digital dexterity is the principal requirement for speed and accuracy in typing and other keyboard tasks for experienced keyboard users. It should be noted that this simple test does not require eye-hand coordination.

Another factor in determining a typist's speed and accuracy might be what is termed information-processing ability, i.e., a typist is required to translate written words into finger movements and the mental process of making this translation may limit a typist's speed. It was not known at the outset of this study whether digital dexterity or the ability to process information is the ultimate limiting factor in speed for most typists, although it was believed that digital dexterity would prove to be more important.

PHASE I EXPERIMENTS

Experimental Design

A Cronus Single Event stopwatch, an electronic timer with a light-emitting diode (LED) display reading in hundredths of seconds, was used to measure successive taps on a key. Depressing the start/stop button on top of the stopwatch causes the timer to begin. A second depression of the button stops the count. A reset button on the face of the stopwatch could be used to reset the count to zero.

Several volunteers were recruited as subjects for testing this device. It was found that the timer could be held comfortably in the palm of either hand, and the index finger of that hand could be used to depress the start/stop button. With the hand held in this position, these subjects attempted

to tap the button twice in rapid succession. The idea was to obtain the fastest time for a double tap. It was found that only a few practice trials (fewer than 10) were required to train a subject and that 30 recorded trials provided sufficient data. It was also discovered that occasionally a subject failed to turn off the timer on the second tap; these errors caused excessive time to be recorded. It was therefore determined that the data analysis should include some method to compensate for these errors.

A second experiment was designed using a Veeder hand counter, a simple mechanical counter that advances one unit on each press of a button. A knob on the side can be used to reset the count to zero. The device is designed to be held in the palm of the right hand and advanced with the thumb, but it can also be operated easily with the left hand.

Dexterity testing using this device was chosen as an alternative to the double tap using the stopwatch. It was intended that the subject would advance the counter as fast as possible for a specific number of counts, the time for the task then being recorded. Testing with our volunteer subjects determined that they could advance the counter 50 times without fatigue.

The above tests require the presence of an observer to instruct the subject and record the data. This requirement was deemed undesirable for two reasons:

1. Nonuniformity of instructions to the subjects might introduce error into the data.

2. If this method were to be employed in a mass screening program for typists, many trained instructors would be required.

Therefore a second set of experiments was devised to automate the data-taking procedure. The equipment consisted of an Apple II microcomputer, an Apple Disk II disk drive, and a television receiver for display. The intent was to use the computer to provide much the same tests as those described above, but to have the computer train the subjects and record the data. A further benefit of this method is that the data, already in machine-readable form, could be easily analyzed by computer.

The double-tap experiment using the stopwatch was to be duplicated by having the subject make a double tap on a key of the computer keyboard. Each subject would be tested for 30 trials, and the data would be automatically recorded on a floppy disk.

The manual counter experiment described above would be duplicated by having each subject make 50 rapid taps on one of the keys on the computer keyboard. The time to make the 50 taps would be recorded automatically on the disk.

In order to time the subjects' responses, it was necessary to write a machine language subroutine on the computer, which would use the Apple II's internal "clock" to measure the time between keystrokes. This subroutine is presented in Appendix A. Using this subroutine, time between keystrokes can be measured to an accuracy of better than 1 millisecond.

A BASIC program was written to present the double-tap and counter experiments to the subjects. The program is contained in Appendix B.

Procedure

With the aid of Dr. Kathleen Drummond, University of Louisville School of Business, and Ms. Sharon Tiller, instructor of typing at the University of Louisville and Jefferson Community College, several beginning typing classes were selected for experimental study. These typing classes were intended for beginning typing students with no previous typing experience.

Four classes were used, three at Jefferson Community College and one at the University of Louisville. There were approximately 120 students in the four classes. Students in the classes were both male and female and ranged in age from 18 to 60. All classes began in January 1980.

At the beginning of the first class of the semester, the principal investigator met with the students to describe the purpose of this research and to begin experimentation. The experiments were described briefly and demonstrated, and the students were invited to participate. It was emphasized that participation was voluntary and would take about 5 minutes. Each participating student filled out a "Typing Experience Questionnaire and Consent Form" (see Appendix C).

Students were then conducted to another room, one at a time, while class was in progress. Dr. Drummond and the principal investigator conducted the four experiments on each subject in turn. While Dr. Drummond was presenting the two manual experiments to a subject, the principal investigator was supervising another in performing the two computer-moderated experiments.

Dr. Drummond would begin by demonstrating the operation of the stopwatch and by instructing the subject in the proper way to hold it. The stopwatch would be held in the palm of the dominant hand and operated with the index finger of the same hand. The subject was then given a few practice trials in the double-tap experiment. When the subject was trained, he or she would perform 30 double taps, reporting each result in turn for the experimenter to record on the "Digital Dexterity Test" form (see Appendix D).

The subject would then be given the Veeder counter and instructed in its use. The counter would be held in the palm of the dominant hand and advanced with the thumb of the same hand. After a little practice, the subject would be timed while advancing the counter from zero to 50 as quickly as possible.

Next the subject would sit down before the computer and begin the automated experiments. When necessary, the experimenter would briefly familiarize the subject with the equipment. The BASIC program would request that the subject type in his or her name and would then instruct the subject on performance of the double-tap experiment (striking a key twice in rapid succession). The subject was then given visual prompts (on the television receiver) in a practice session for the double-tap experiment. This was followed by 30 timed double-tap tests. After their completion, the results were automatically recorded on the disk.

The program next presented the subject with instructions on the automated counter test (50 rapid taps on a single key), provided a short practice session, and proceeded with the test. The results were automatically recorded on the disk.

Appendix E contains a sample run of the BASIC program. No printed (hard-copy) output occurred during the conduct of the experiment; all output simply appeared on the television screen.

After the experiment was completed, the subject was given a $3.00 payment and returned to the classroom.

After completion of the courses, the students' typing scores were obtained from the teacher. These scores consisted of the results of one or more timed 5-minute speed tests with the results expressed in gross words per minute and number of errors.

At the end of the term, the above experiments were to be repeated on some of the students to determine if typing training improves dexterity test measurements.

It is recognized that students completing an introductory typing course cannot be considered experienced typists; therefore the plan was to conduct follow-up tests if the results of the one-semester experiment were encouraging.

Results

The original intent of this research was to test formally the hypothesis that the speed with which a person can perform these tests is a measure of inherent digital dexterity and that this dexterity measurement can be used as a predictor of success at typing.

In early May 1980, scores on typing tests were obtained from the teachers of the courses. These scores were the results of timed (5-minute) tests of typing speed measured in words per minute. Of the original 103 subjects who had been given the dexterity tests, 52 completed the typing courses and are included in this study.

In trying to assess possible correlations between the dexterity tests and typing speed, six dexterity variables were considered:

1. Best tap time manually (BTM): Of the 30 trials requiring the subject to depress and release the start/stop button twice in succession, with the times being recorded manually from the stopwatch, the best time (least amount of time required) is the first variable (in hundredths of seconds).

2. Mean of the best 10 tap times manually (MBTM): This variable is similar to the first, except that the average (mean) of the best 10 times is being used (in hundredths of seconds).

3. Counter time manually (CTM): This is the time, recorded manually from the stopwatch, required by the subject to advance the counter from zero to 50 (in seconds).

4. Best tap time automated (BTA): This variable, similar to the first, is the best time required by the subject to strike the space bar on the Apple II keyboard twice in succession (in thousandths of seconds).

5. Mean of the best 10 tap times automated (MBTA): The average of the 10 best times required by the subject to strike the space bar on the Apple II (in thousandths of seconds).

6. Counter time automated (CTA): The time required by the subject to strike the space bar on the Apple II 50 times in succession (in thousandths of seconds).

The means of the best 10 tapping times were used instead of the means of all 30 times to eliminate any possible outlying data due to the subjects' errors and unfamiliarity with the equipment and to help eliminate any confounding effects due to the subjects' past experience.

Using the simple correlation coefficient as a measure of association between typing speed (words per minute uncorrected for typing errors) and the six variables described above, typing speed was most highly correlated with the best tapping time recorded manually (BTM), with a correlation coefficient $r = .315$. The square of this value, .099, describes the amount of variation in typing speed which can be explained by the best tapping time. Only 10% of the typing speed variation could be explained by variable one. Table 1 lists each of the six variables and that variable's correlation with typing speed (r).

Table 1

Correlation of Dexterity Tests with Typing Speed

Variable	r
Best tap time manually (BTM)	.315
Mean best tap time manually (MBTM)	.254
Counter time manually (CTM)	.016
Best tap time automated (BTA)	.055
Mean best tap time automated (MBTA)	-.036
Best counter time automated (CTA)	.024

Figures 1 through 6 show graphically the association between typing speed and the six variables.

Since most of the six variables were not highly correlated with each other, multiple regression techniques were used to determine whether several of the variables in combination would better predict typing speed. The best multiple regression equation was obtained using all except MBTM as independent variables. This resulted in a multiple correlation coefficient of .39. While this does represent an improvement over a regression equation using only a single variable, it requires using five variables and only 15.2% of the variation in typing speed can be accounted for by the variables.

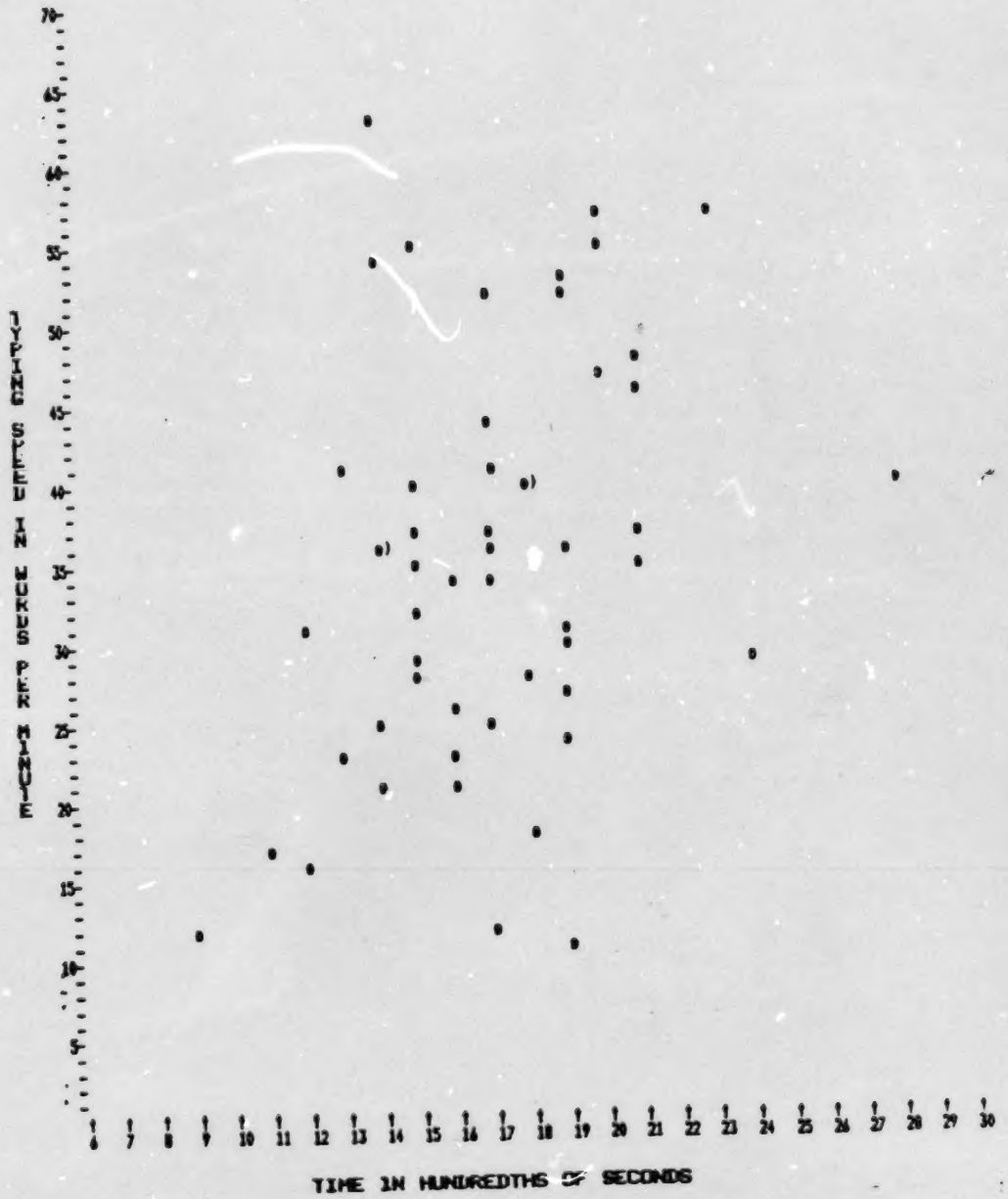


Figure 1. BTM, all January classes, manual data entry, best score.

Figure 2. MBTM, all January classes, manual data entry, mean of best 10.

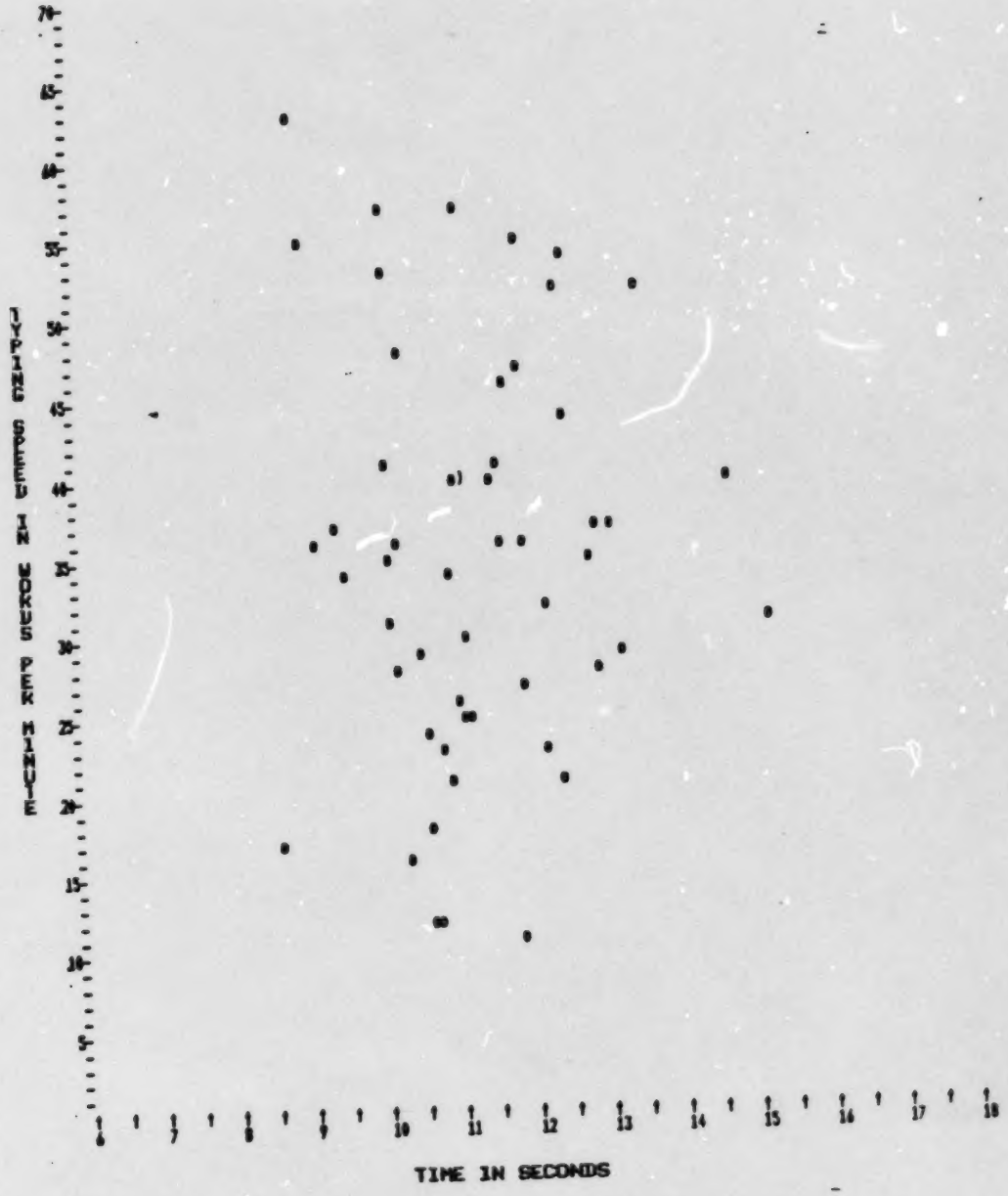


Figure 3. CTM, all January classes, manual data entry, counter.

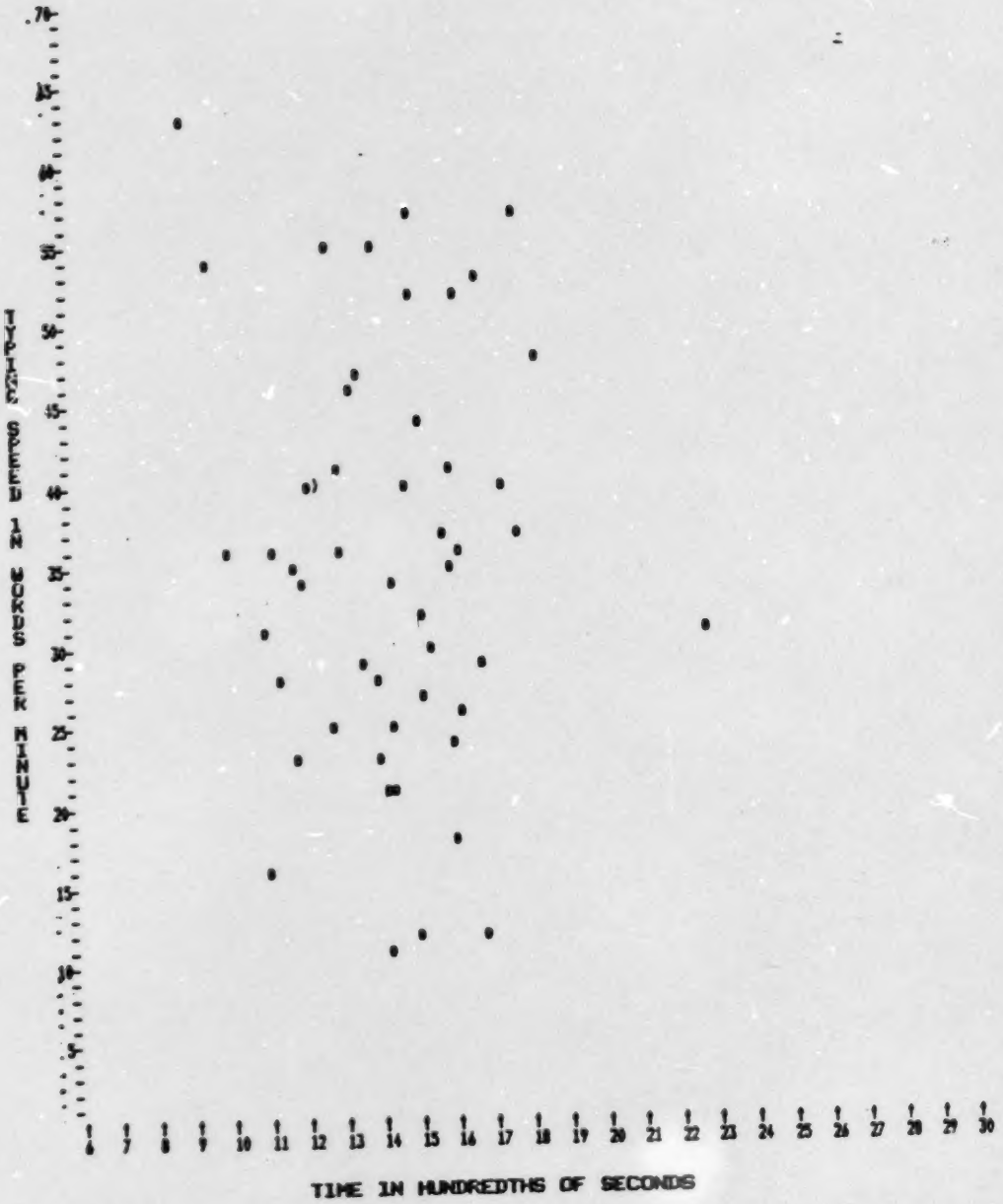


Figure 4. BTA, all January classes, automated data entry, best score.

Figure 5. MBTA, all January classes, automated data entry, mean of best 10.

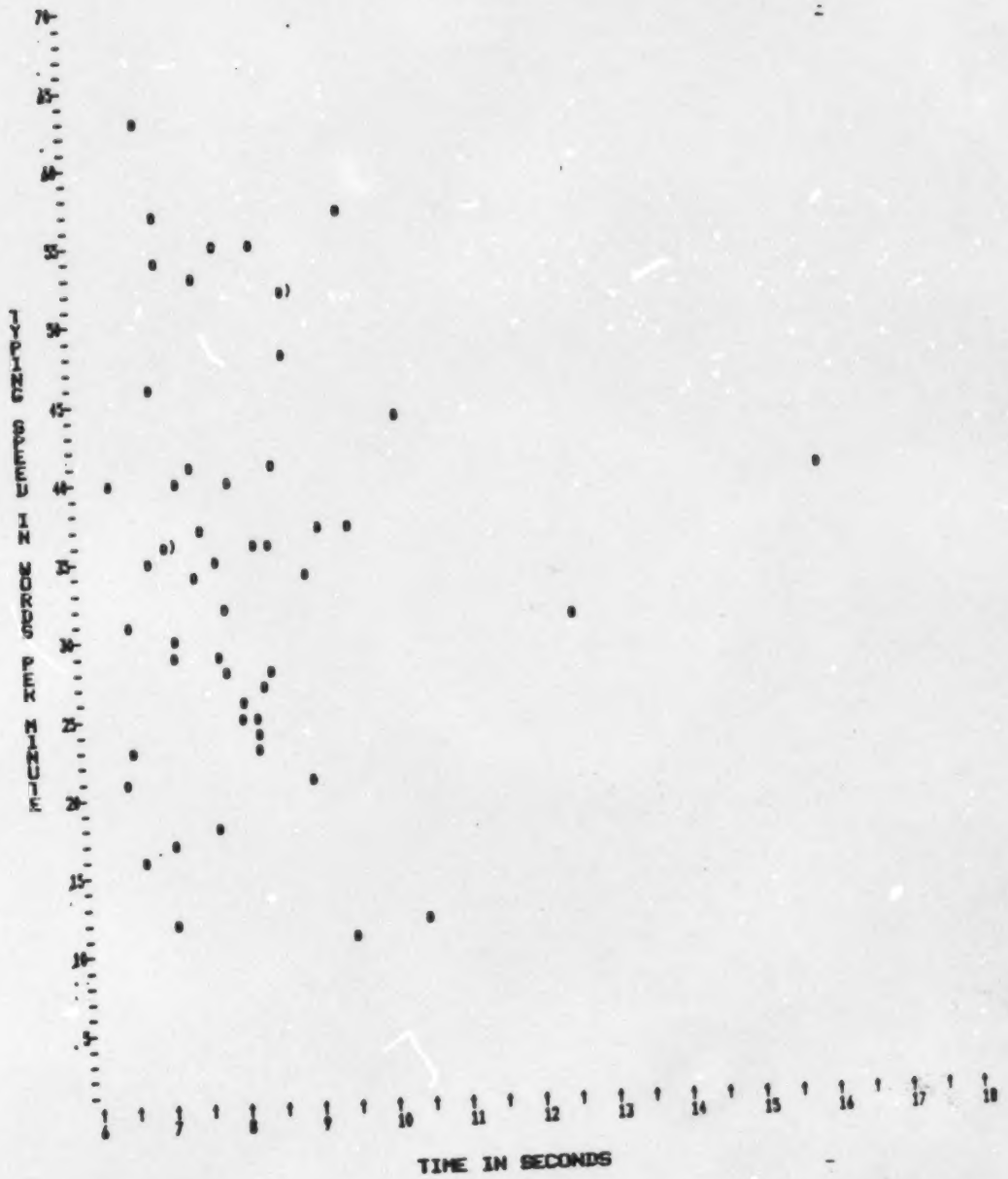


Figure 6. CTA, all January classes, automated data entry, counter.

The goal was not to predict the subject's actual typing speed, but to determine whether the dexterity tests would help to distinguish between poor typists and good typists. The original 52 subjects were divided into two groups; the first group consisted of subjects whose typing speed was less than 35 words per minute, and the second group consisted of those whose typing speed was at least 35 words per minute. For each group, the means of the six dexterity variables were calculated and the results are given in Table 2. For none of the variables did the means differ significantly between the poor typists and the good typists. In some cases, the good typists had faster times than the poor typists; and in other cases, the good typists had slower times.

Table 2

Means of Dexterity Variables for Poor vs. Good Typists

Variable	Typing speed <35		Typing speed >35
Best tap time manually (BTM)	15.96	<	17.96
Mean best tap time manually (MBTM)	17.98	<	19.80
Counter time manually (CTM)	11.27	>	11.24
Best tap time automated (BTA)	139.09	>	138.28
Mean best tap time automated (MBTA)	159.02	>	154.11
Best counter time automated (CTA)	8058.00	<	8359.80

One remaining question of interest was how the subjects' past typing experience was related to the dexterity tests. Of the 52 subjects in the study, 17 stated that they had had no previous typing experience, and 35 listed some form of typing experience. Table 3 gives the mean times of the six dexterity variables and mean typing speed for each group.

Table 3

Means of Typing Speed and Dexterity Variables

Variable	Experienced (N = 35)		Not experienced (N = 17)
Typing speed	35.59	>	24.96
Best tap time manually (BTM)	17.49	>	15.88
Mean best tap time manually (MBTM)	19.27	>	18.09
Counter time manually (CTM)	11.33	>	11.11
Best tap time automated (BTA)	140.82	>	134.29
Mean best tap time automated (MBTA)	158.38	>	152.95
Best counter time automated (CTA)	8323.90	>	7972.30

The difference in mean typing speeds of the experienced and nonexperienced groups is significant at the .01 level, but the differences between these groups on the dexterity tests is not significant. This means that previous typing experience is related to the typing speed at the end of a one-semester typing course, as was expected, but that the dexterity tests do not detect this typing experience.

In fact, it is interesting to note that the experienced group actually averaged greater times on the dexterity tests than the nonexperienced groups. And as witnessed by the positive correlation coefficients between typing speed and most of the dexterity variables, it appears that the better typists actually took more time to complete the dexterity trials. (Note that the r-value being so close to zero for variables 3 through 6 indicates no real correlation.)

Correlations between typing speed and the dexterity variables were examined for the 35 subjects who had had some previous typing experience. For this group, typing speed was most highly correlated with the mean of the best 10 tapping times (manual), $r = -.188$, and with the best tapping time (manual), $r = .16$.

For the group of 17 subjects with no previous typing experience, the variables most highly correlated with typing speed are the mean of the best 10 tapping times (manual), $r = .476$, and the best tapping time (manual), $r = .42$. While these correlations are significant, they are suspect due to the small sample size. And their predictive use would be limited, because the majority of people have had some typing experience.

Conclusions

The low correlation coefficients obtained indicate that the simple dexterity tests used are not predictive of success at typing after a one-semester introductory typing course. It should be remembered that the original hypothesis of this research was that well-trained typists would be limited in speed by their digital dexterity (as measured by our simple tests). This hypothesis has been neither proved nor disproved by the foregoing, but it has been shown that early success at typing is not highly correlated with such digital dexterity.

It may be that the dexterity tests are useful in predicting the ultimate speed attainable by a typist, but useless in predicting the rate of progress toward the goal. If true, the speed attained in an introductory course should not be expected to correlate well with dexterity. However, the discouraging results did not make it appear desirable to pursue follow-up studies using dexterity tests.

Although the course was intended as introductory, the students entering the course had a wide range of typing experience. Many who used the touch method had already taken other typing courses or used the typewriter in their work. This made the data difficult to analyze. Indeed, it was found that typing speed upon completion of the course was more dependent on previous experience than on any of the factors measured.

It was therefore decided to abandon digital dexterity tests. As an alternative, the role of information processing ability in the prediction of success at typing would be considered.

PHASE II EXPERIMENTS

Experimental Design

A different approach to prediction of early success at typing was clearly in order. Advice was obtained from Grace Fivars, one of the inventors of the previously described tapping test. She suggested the use of tests that would measure the ability to use the fingers independently and to associate a character with a particular finger. She said that the tapping test has shown that these are the important abilities to test.

Keeping in mind that a simple, easy-to-administer test is most desirable for screening potential typists, it was also decided to measure the reaction time of the subjects. It should be noted that reaction time denotes the speed of a response that follows a stimulus, e.g., the speed of response of a driver who sees the brake lights of another car. This is quite different from what is measured in digital dexterity tests such as the double-tap experiment. In the double-tap experiment, the time the subject spent before depressing the key the first time was not measured; only the time between the two keystrokes was recorded, thus there was no measurement of reaction time to a stimulus.

Based on the above considerations, three experimental procedures were devised: one to measure reaction time, one to measure the ability to use the fingers independently, and one to measure the ability to associate a character with a finger. It was decided to implement all three procedures on the Apple II computer, using the keyboard as the input device.

To use the computer for this purpose, it was necessary to write a machine language subroutine to time the subjects' responses. The subroutine, shown in Appendix F, is quite similar in concept to the timing subroutine shown in Appendix A.

In the first experiment, the subjects were to press the space bar as fast as possible after receiving a visual stimulus. The reaction time would be recorded on disk.

In the second experiment, the subjects were to type eight keys in sequence. In one sequence, the subjects would type using the little, ring, middle, and index fingers of the left hand followed by the index, middle, ring, and little fingers of the right hand. This amounts to "rippling" the fingers over the keys from left to right. In the other sequence, the subjects would type the keys in reverse order, rippling the fingers from right to left. The time to respond to the stimulus (the time before the first character is struck), the total time to complete the eight-key sequence, and the number of errors would be recorded on disk. This experiment was expected to measure the ability of the subjects to use their fingers independently. However, it also might be expected to depend upon the subjects' "information processing" ability; i.e., the subjects must process the stimulus (requesting that they type either from right to left or from left to

right), and the time they take to do this is recorded. Therefore, the time between the stimulus and the first keystroke may be dependent on both the subjects' raw reaction time and the speed with which they can process the stimulus information.

In the third experiment, the subjects were to type a three-key sequence of characters in response to the three random characters that would appear on the screen. The time to type the first character, the total time to type all three characters, and the number of errors would be recorded on disk. This experiment was expected to measure the subjects' ability to associate a character with a finger.

It is recognized that the third experiment will favor the student with typing experience. This is not seen as a drawback in the following context: Students entering beginning typing courses can be expected to have widely varying experience in typing. Indeed, the results from Phase I of the experiments indicate that some entering students have considerable experience, and our results also show that a student's typing speed at the end of the course is well correlated with this experience. Therefore, an experimental procedure that favors experienced typists may well be more successful at predicting typing speed than one that does not.

A listing of the BASIC program that executes the experiment is contained in Appendix G.

Procedure

Students from four beginning typing classes were used as subjects for these experiments. One of the classes was at the University of Louisville; the other three were at Jefferson Community College. All classes were taught by Ms. Sharon Tiller during the summer term of 1980. There were approximately 80 students in the four classes.

Early in the semester (on or before the third class meeting), the principal investigator met with the students to describe the purpose of the research and to begin experimentation. Conduct of the computer-moderated experiments was demonstrated, and each voluntarily participating student filled out a "Typing Experience Questionnaire and Consent Form" (Appendix C).

Students were conducted one at a time to another room where they sat down before the computer, supervised by the principal investigator. The BASIC program would request the subjects' name and sex; then it would ask if the subject had any previous typing experience.

The first experiment instructed the subjects to strike the space bar whenever "GO!" appeared on the display. After a short practice session, 10 trials were conducted and reaction time was recorded.

The second experiment directed the subjects to position their fingers over the "ASDFJKL;" keys. This is the standard "home" position for the typewriter and for the computer keyboard. Subjects were then directed to type the sequence A-S-D-F-J-K-L-; when the word "LEFT" appeared on the screen and ;-L-K-J-F-D-S-A when the word "RIGHT" appeared. The subjects were then

given trials until they could successfully complete the sequence in each direction. Then the test was repeated 20 times--10 for "RIGHT" and 10 for "LEFT," randomly mixed. Three data were recorded for each of the 20 tests: the time between presentation of the stimulus and striking the first key, the total time to input all characters, and whether there was an error in the character entry.

The third experiment directed the subjects to hold their fingers in the same position (home) and to type the three characters that appeared on the screen, e.g., "ADK." The three characters were any of the following: A, S, D, F, J, K, L,;, i.e., any of the eight characters from the home position. The subjects were given repeated three-letter combinations until they got two sequences correct; then 10 timed trials were given. Three data were recorded for each of the 10 trials: the time between display of the letters on the screen and striking the first character, the total time to enter all three characters, and whether there was an error in the character entry.

After completion of the experiment the subjects were given a $3.00 payment and returned to the classroom.

Appendix H contains a sample run of the BASIC program.

The instructor provided the students' typing scores at the end of the course. As before, these scores consisted of one or more timed 5-minute speed tests in which gross typing speed (in words per minute) and number of errors were reported.

Results

In trying to determine if the quantities measured during these tests could be used to predict typing speed, it was necessary to decide upon possible variables to be used. The 26 variables chosen are described below.

I. Two variables are from the first test measuring reaction times:

1. the best reaction time (BRT_1)

2. the mean of the best five reaction times ($\overline{BRT}_1$)
(both recorded in thousandths of seconds)

II. Twelve variables chosen pertained to the second test, which measures the ability to use the fingers independently:

A. Six variables were chosen from the 20 trials of each subject, regardless of whether errors were made or not:

3. the best total time (BTT_{21})

4. the best reaction time (time from stimulus to striking of first character) (BRT_{21})

5. the best difference in times between the total time and the initial reaction time. This time corresponds to the actual typing of the sequence of letters. (BDT_{21})

6. the mean of the best five total times ($\overline{BTT}_{21}$)

7. the mean of the best five reaction times ($\overline{BRT}_{21}$)

8. the mean of the best five differences in total time minus reaction time ($\overline{BDT}_{21}$)

B. The remaining six variables are similar to the six just described, except they were formed from only the trials that were performed without errors.

9. the best total time (BTT_{22})

10. the best reaction time (BRT_{22})

11. the best difference in times (BDT_{22})

12. the mean of the best five total times ($\overline{BTT}_{22}$)

13. the mean of the best five reaction times ($\overline{BRT}_{22}$)

14. the mean of the best five differences in times ($\overline{BDT}_{22}$)

(All variables for Test II are recorded in thousandths of seconds.)

III. The third part of the tests measured the ability to associate a character with a finger. The 12 variables considered here are similar to those used with the second part of the test.

A. The following six variables are formed using all 10 trials:

15. the best total time (BTT_{31})

16. the best reaction time (BRT_{31})

17. the best difference in times (BDT_{31})

18. the mean of the best five total times ($\overline{BTT}_{31}$)

19. the mean of the best five reaction times ($\overline{BRT}_{31}$)

20. the mean of the best five differences in times ($\overline{BDT}_{31}$)

B. The remaining six variables are formed from only the trials performed with no errors:

21. the best total time (BTT_{32})

22. the best reaction time (BRT_{32})

23. the best difference in times (BDT_{32})

24. the mean of the best five total times ($\overline{BTT}_{32}$)

25. the mean of the best five reaction times ($\overline{BRT}_{32}$)

26. the mean of the best five differences in times ($\overline{BDT}_{32}$)

(All 12 variables are recorded in thousandths of seconds.)

Also recorded for each subject were the subject's sex, previous typing experience, and the number of errors made on parts 2 and 3 of the tests. Means are found using the best five trials instead of all trials to compensate for excessively large times sometimes obtained by the subjects when errors were made.

Of the original 43 subjects who were administered the tests at the beginning of the summer semester typing courses, 34 completed the course and are included in this study.

Initially, it was hoped to get an idea of how the poorer typists and better typists compared to each other in terms of these variables. The sample of 34 subjects was divided into two groups: students whose typing speed at the end of the semester was less than 35 words per minute (uncorrected for typing errors), and those whose typing speed was at least 35 words per minute (uncorrected for typing errors). The means of the variables for each group were then found and are given in Table 4. For all variables except the two from part 1, the better typists had done better on the pre-typing-class tests. The next step was to examine the apparent relationship between the pretest and typing speed.

Next, each of the 26 variables described above was plotted as independent variables versus typing speed (see Figures 7 to 14 for sample plots). After examining these plots, there appeared to be two possible relationships between the independent variable and typing speed, either linear or reciprocal. Therefore, it was decided to investigate these two types of relationships.

The model underlying a linear relationship can be expressed in the form

$$Y = a + bX + \epsilon$$

where Y is typing speed, X is one of the 26 independent variables, and ϵ represents random errors. The method of least squares, which minimizes the amount of error, was used to estimate a and b in the equation. Two quantities that are used to judge the effectiveness of the fit of the curve are the correlation coefficient, r, and the standard error of Y about the regression line, denoted $s_{y/x}$. The square of the correlation coefficient, r^2, represents the fraction of the variation in typing speed that can be explained by means of the prediction equation. The easiest way to interpret $s_{y/x}$ is as a measure of the average amount the actual typing speeds differ from the estimated mean typing speeds. Ideally, one would like the r^2 value to be as close to 1 as possible, and $s_{y/x}$ to be as small as possible. A more realistic goal of r-values around .5 was decided on from comparison with the results reported by John C. Flanagan (1963, p. 12) in the Manual for the Tapping Test, where his r-values ranged from .12 to .63, with an average of .39.

Table 4

Means of Predictive Variables for Two Groups of Typists

Variable	Typing speed[a] <35 (N = 17)		>35 (N = 17)
BRT_1	213.12	<	236.35
$\overline{BRT}_1$	246.88	<	264.35
BTT_{21}	2395.10	>	1880.90
BRT_{21}	502.06	>	472.18
BDT_{21}	1649.70	>	1265.50
$\overline{BTT}_{21}$	2537.20	>	2009.00
$\overline{BRT}_{21}$	622.65	>	547.53
$\overline{BDT}_{21}$	1773.00	>	1363.60
BTT_{22}	2423.8	>	1905.60
BRT_{22}	563.18	>	484.41
BDT_{22}	1668.30	>	1283.20
$\overline{BTT}_{22}$	2565.20	>	2027.80
$\overline{BRT}_{22}$	654.29	>	561.18
$\overline{BDT}_{22}$	1789.50	>	1380.10
BTT_{31}	1852.60	>	1439.90
BRT_{31}	1067.40	>	835.82
BDT_{31}	598.53	>	465.59
$\overline{BTT}_{31}$	2195.90	>	1693.90
$\overline{BRT}_{31}$	1232.50	>	993.29
$\overline{BDT}_{31}$	806.29	>	594.88
BTT_{32}	1876.50	>	1453.80
BRT_{32}	1097.70	>	838.59
BDT_{32}	598.53	>	486.94
$\overline{BTT}_{32}$	2253.10	>	1782.10
$\overline{BRT}_{32}$	1295.00	>	1036.90
$\overline{BDT}_{32}$	836.35	>	644.65

[a]Gross typing speed is used, uncorrected for typing errors.

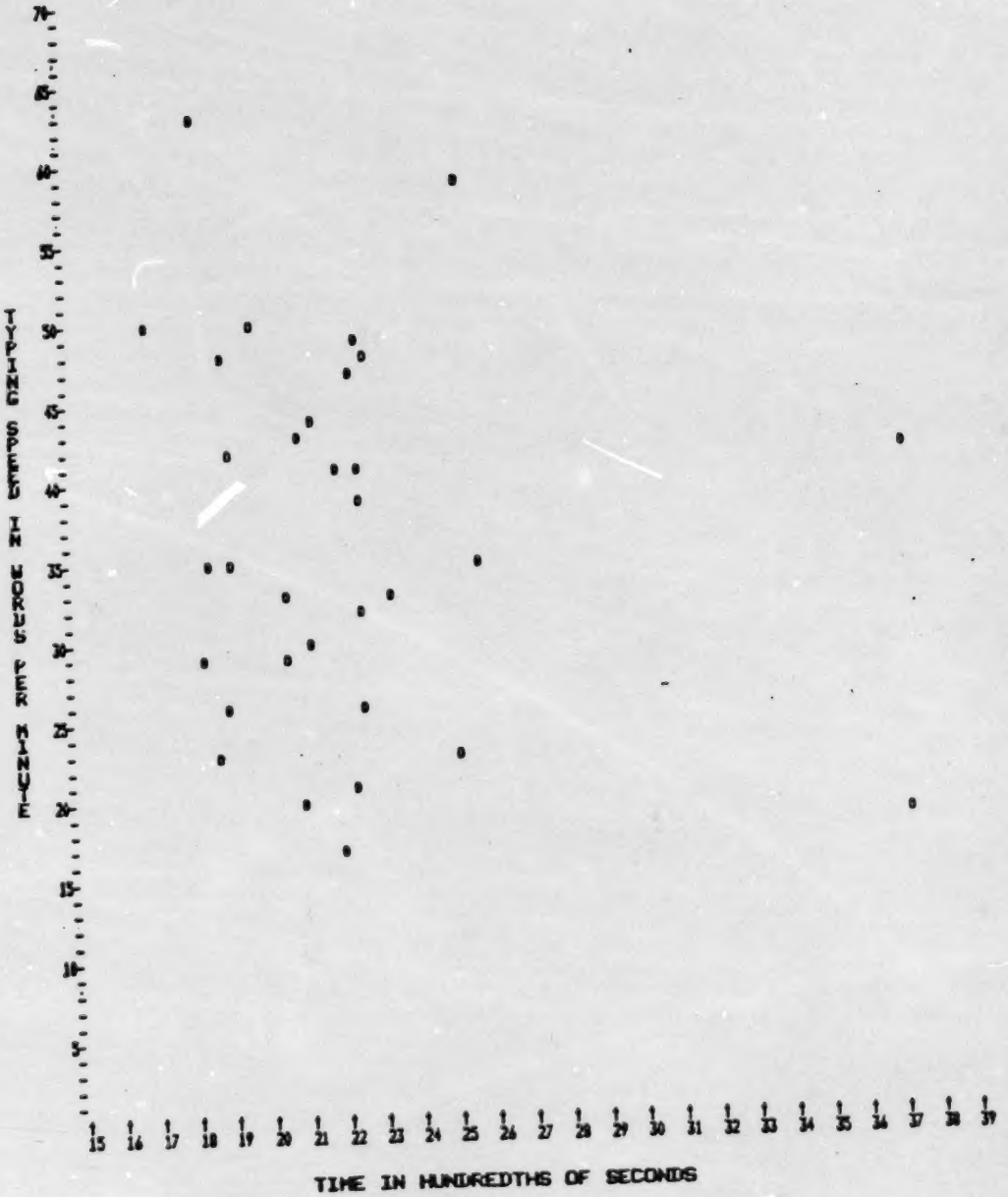


Figure 7. BRT_1, all summer classes, best reaction time, correlation coefficient = .247693395.

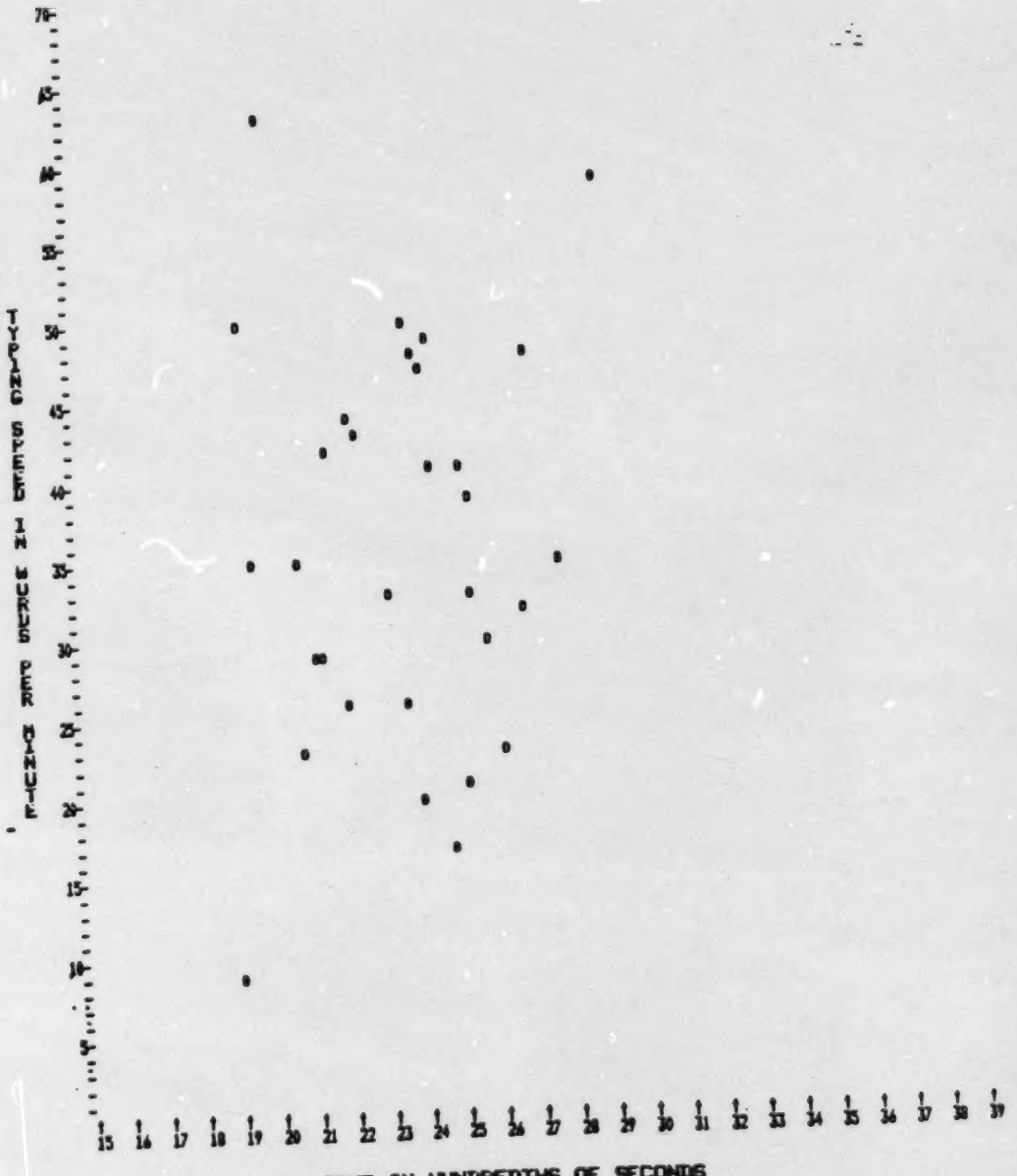


Figure 8. $\overline{BRT}_1$, all summer classes, mean of best 5 reaction times, correlation coefficient = .152882302.

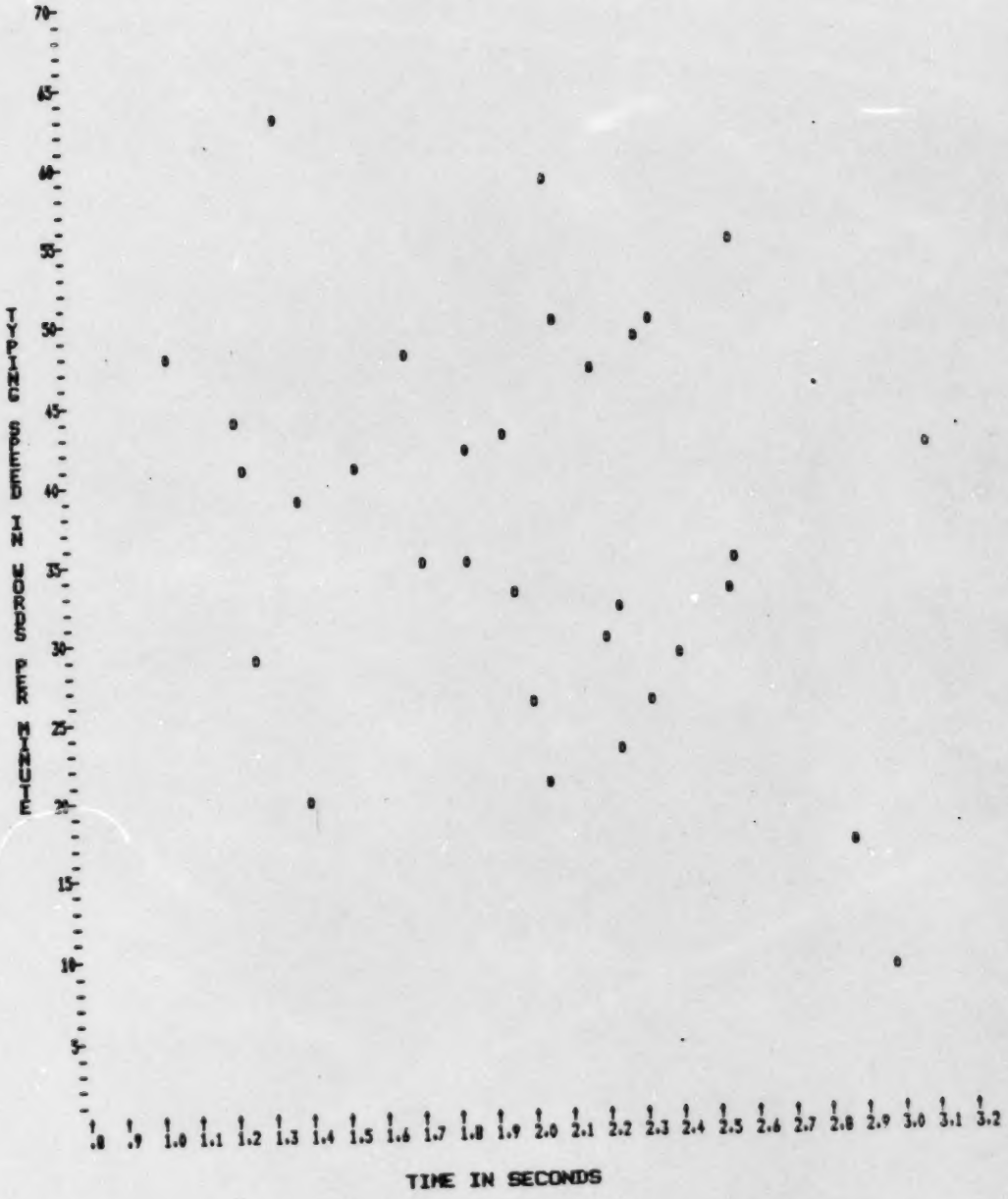


Figure 9. BTT_{21}, all summer classes, best independent finger dexterity input time, correlation coefficient = -.417334614.

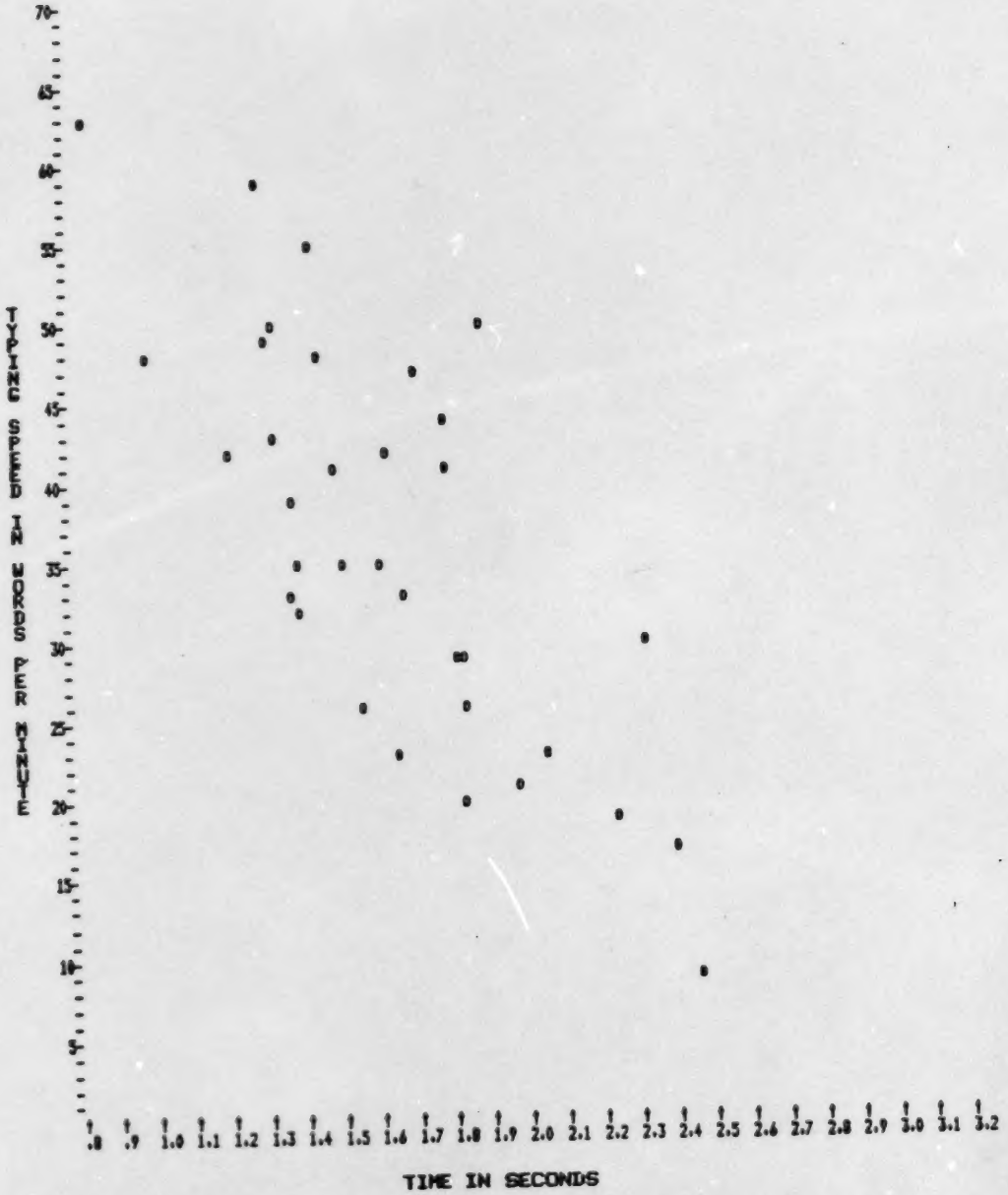


Figure 10. BTT_{31}, all summer classes, best character input time, correlation coefficient = -.745920726.

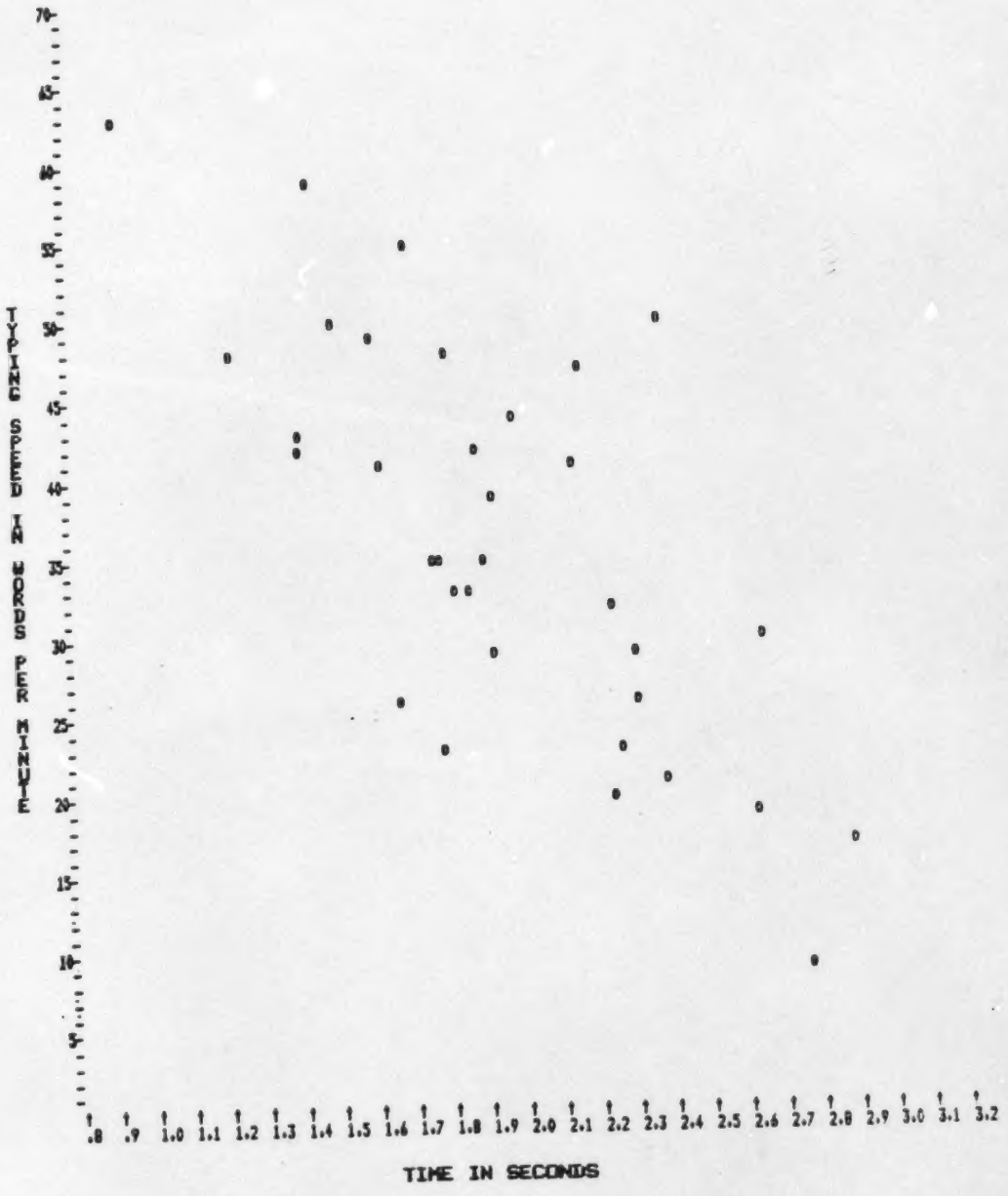


Figure 11. $\overline{BTT}_{31}$, all summer classes, mean of best 5 character input times, correlation coefficient = -.72321515.

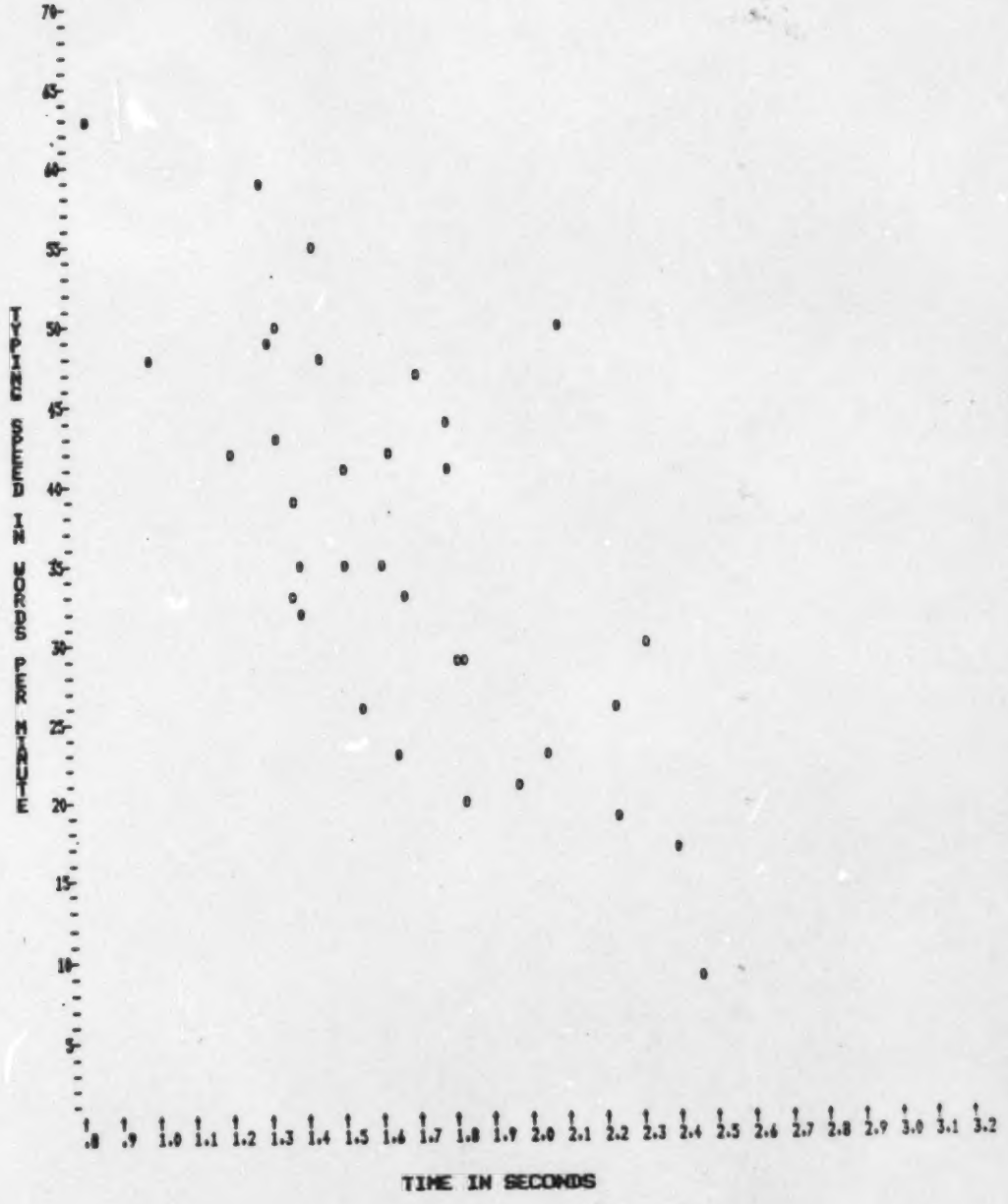


Figure 12. BTT_{32}, all summer classes, best correct character input time, correlation coefficient = -.720618611.

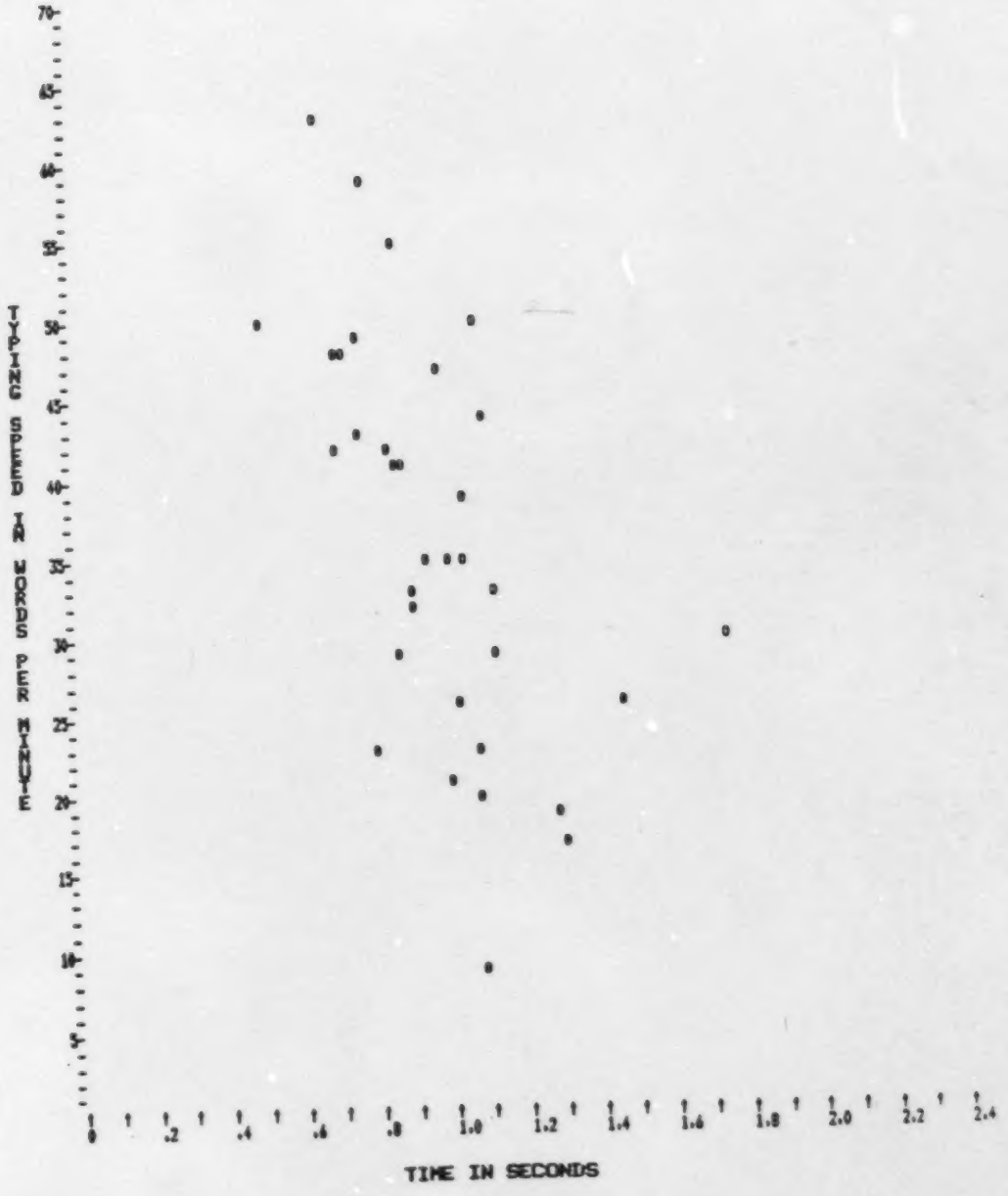


Figure 13. BRT_{32}, all summer classes, best correct character reaction time, correlation coefficient = -.57066121.

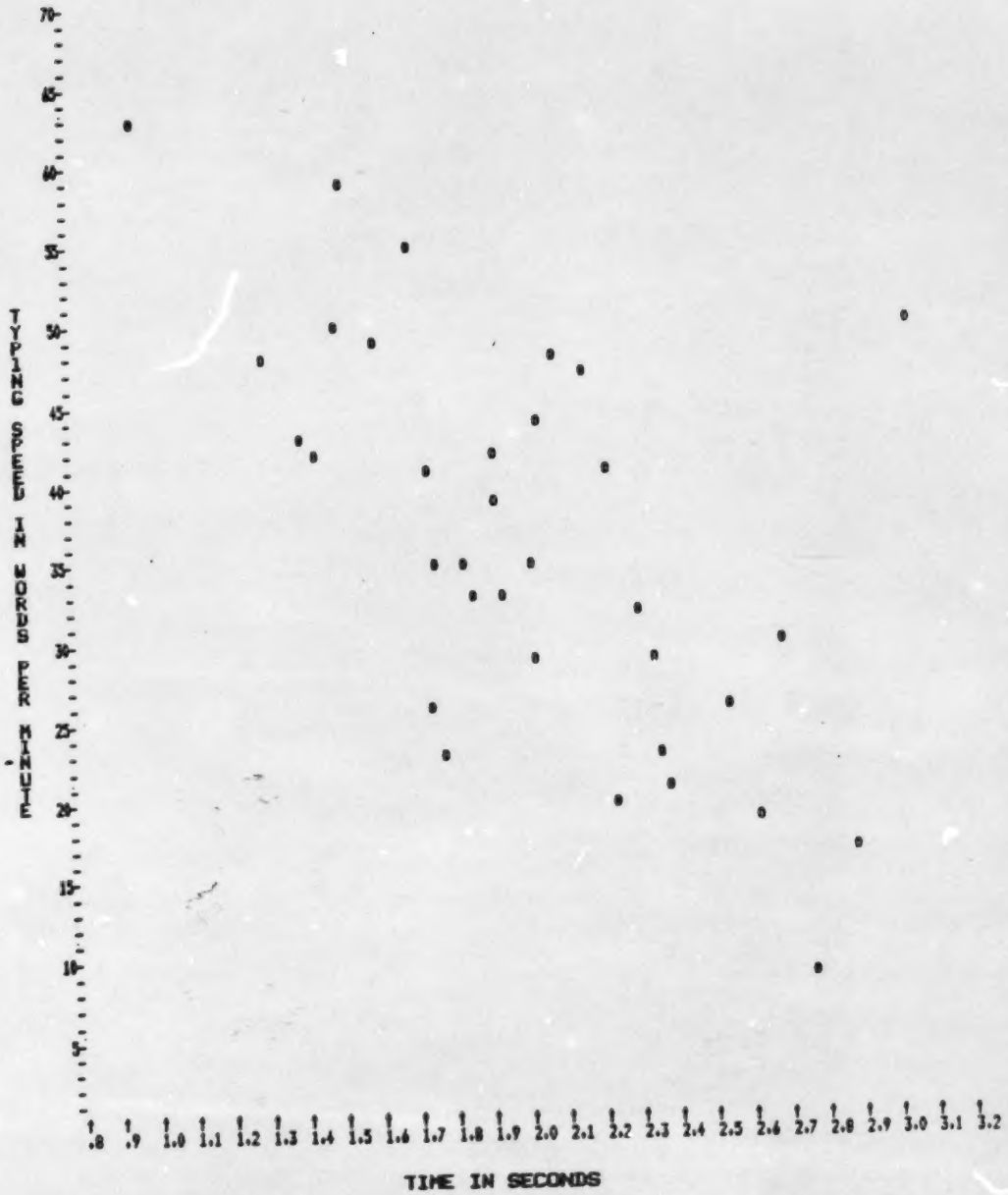


Figure 14. $\overline{BTT}_{32}$, all summer classes, mean of best 5 correct character input times, correlation coefficient = -.624069803.

Results of the linear regression of typing speed on each of the 26 independent variables (one at a time) are given in Table 5.

Table 5

Linear Regression of Typing Speed on Pretyping Variable

Variable	Correlation coefficient (r)	Standard error $s_{y/x}$
BRT_1	.249	12.60
$\overline{BRT}_1$	.154	12.80
BTT_{21}	-.417	11.80
BRT_{21}	-.072	13.00
BDT_{21}	-.374	12.00
$\overline{BTT}_{21}$	-.407	11.90
$\overline{BRT}_{21}$	-.166	12.80
$\overline{BDT}_{21}$	-.399	11.90
BTT_{22}	-.427	11.70
BRT_{22}	-.227	12.60
BDT_{22}	-.390	12.00
$\overline{BTT}_{22}$	-.414	11.80
$\overline{BRT}_{22}$	-.217	12.70
$\overline{BDT}_{22}$	-.407	11.90
BTT_{31}	-.746	8.65
BRT_{31}	-.552	10.80
BDT_{31}	-.557	10.80
$\overline{BTT}_{31}$	-.723	8.97
$\overline{BRT}_{31}$	-.551	10.80
$\overline{BDT}_{31}$	-.588	10.50
BTT_{32}	-.721	9.00
BRT_{32}	-.571	10.70
BDT_{32}	-.482	11.40
$\overline{BTT}_{32}$	-.624	10.10
$\overline{BRT}_{32}$	-.512	11.20
$\overline{BDT}_{32}$	-.477	11.40

Several interesting results surface from these analyses. First, for the two variables that relate to part 1 of the tests and measure only reaction time, the correlation coefficients are positive and small. The positive correlations are counter to what would have been expected, but agree with the results noted in the Phase I tests. The small correlations also agree with the earlier results. Based on this evidence, any test that measures only reaction time would not be sufficient to predict typing speeds.

Secondly, variables from part 2 of the tests, which measure finger dexterity, have moderate correlations ranging from -.07 to -.43. That is, at best, approximately 16% of the variation in typing speeds can be explained by a linear relationship with one of these variables. While this is statistically significant, it was hoped to do better. Also, the highest correlations are occurring with the variables from part 2 which use the total time, i.e., the initial reaction time, the time required for the subjects to think about rippling their fingers and then to perform the rippling. Thus, it seems that it is necessary to include some measure of the thought process, as opposed to only the reaction time or only the actual performance time.

The best results were obtained with the variables from part 3 of the test. The correlation coefficients range from -.48 to -.75; thus, using the most highly correlated variable, more than 50% of the variation in typing speeds can be explained by the linear function of that one variable. As seen in part 2, the variables most highly correlated with typing speed are those that use the total time to complete the task.

When comparing the results from parts 1, 2, and 3, the more the task performed by the subject requires the subject to associate thoughts with finger manipulation, the higher the correlation is with typing speed. This suggests that a very simplified version of a typing test may best predict the typing speed at the end of an introductory course.

Table 6 shows convincingly the effectiveness of BTT_{31} (best total time for part 3, disregarding errors), the most highly correlated variable with typing speed, as a predictor of typing speed at the end of one semester. Students who perform better on part 3 of the test (less time) are able to type faster.

Table 6

Typing Speed at the End of One Semester by Students with Various Score Levels on the Predictive Variable

BTT_{31} score	N	Below 20	20-34.9	35 or more
Below 1350	7	0	0	7
1350 to 1649	11	0	5	6
1650 to 1949	10	1	5	4
1950 to 2249	3	1	2	0
2250 or more	3	2	1	0

Typing speed is inversely proportional to the amount of time it takes to strike a key. Therefore, it might be expected that an inverse relationship might exist between typing speed and the measured times we obtained on our tests.

The model for the reciprocal relationship is of the form

$$y = a + \frac{b}{x} + \varepsilon$$

where y is typing speed, x is the independent variable, and ε represents the random errors. Results very similar to the linear case were obtained and are shown in Table 7 for the variables in part 3.

Table 7

Correlations and Standard Errors for Typing Speed Regressed Reciprocally on the Independent Variable

Variable	Correlation coefficient r	Standard error, $s_{y/x}$
BTT_{31}	.72	9.05
BRT_{31}	.59	10.50
BDT_{31}	.53	11.00
$\overline{BTT}_{31}$	.69	9.34
$\overline{BRT}_{31}$	.60	10.40
$\overline{BDT}_{31}$	.55	10.80
BTT_{32}	.70	9.23
BRT_{32}	.61	10.30
BDT_{32}	.50	11.20
$\overline{BTT}_{32}$	.65	9.85
$\overline{BRT}_{32}$	.56	10.80
$\overline{BDT}_{32}$	.54	10.90

Just as in the linear case, the variables measuring total time for trials in part 3 are the ones most highly correlated with typing speed. The reciprocal model is not an improvement over the linear model, but comparable to it for the range of values.

The results presented up to now incorporate only one of the variables in the regression equation. The next step was to use several independent variables in combination to better predict typing speed, with the goal of avoiding a terribly complicated formula. Due to the high correlations between

several of the independent variables, various multiple regression techniques were tried. The general form of the multiple regression equation used is

$$y = a + bx_1 + \ldots + cx_n + \varepsilon$$

where y is typing speed, ε represents the random errors, and the $x_1,\ldots,x_n$ are n independent variables. The basic goal was to improve upon

$$y = a + bx, \quad (x = BTT_{31})$$

$$\text{where } R = .746 \text{ and } s_{y/x} = 8.65$$

but to keep n relatively small. The best results from the multiple regression techniques are summarized in Table 8.

Table 8

Regression of Typing Speed on Various Independent Variables

Number of variables	Variables	Correlation coefficient, R	Standard error, s
1	BTT_{31}	.75	8.65
1	$\overline{BTT_{31}}$	.72	8.97
1	BTT_{32}	.72	9.00
2	BDT_{31}, $\overline{BTT_{31}}$	.73	9.07
2	$\overline{BTT_{31}}$, BTT_{32}	.78	8.31
3	$\overline{BTT_{31}}$, BTT_{31}, $\overline{BRT_1}$	.81	7.81
(1) 3	$\overline{BDT_{31}}$, BRT_{32}, $\overline{BDT_{32}}$	.81	7.89
3	BDT_{31}, $\overline{BTT_{31}}$, BDT_{32}	.80	8.03
(2) 4	BRT_{31}, $\overline{BDT_{31}}$, BRT_{32}, $\overline{BDT_{32}}$	.84	7.31
4	BDT_{31}, $\overline{BTT_{31}}$, BRT_{32}, BDT_{32}	.81	8.00
4	$\overline{BTT_{31}}$, BTT_{32}, $\overline{BRT_1}$, BDT_{22}	.83	7.57
5	$\overline{BRT_1}$, BRT_{31}, $\overline{BDT_{31}}$, BRT_{32}, $\overline{BDT_{32}}$	.87	6.86

There is no unique answer as to which combination of predictor variables is best and of how many predictor variables to use. Using two variables will not offer a significant improvement over using only one variable, but using three or four variables does increase the correlation coefficient significantly and decreases the standard error significantly. The regression equations using the variables indicated in (1) and (2) have the additional advantage that only part 3 of the pre-typing-class test needs to be performed. The predictor variable most highly correlated with typing speed, BTT_{31}, is not used in the multiple regression cases. This was because BTT_{31} was very highly correlated with the other predictor variables, so that including other variables with it did not give a significant improvement over using only that variable.

In summarizing the results of the various regression analyses, there appear to be several fairly comparable models that could be used to describe the relationship between typing speed and the scores on the pre-typing-class test. The models with the best fits to the data are given below, with their corresponding summary statistics. (Y = typing speed)

1. $Y = 78.23 - .0255\ (BTT_{31})$ $R = .75$ $s = 8.65$

2. $Y = 76.44 - .0206\ (\overline{BTT}_{31})$ $R = .72$ $s = 8.97$

3. $Y = 75.47 - .0235\ (BTT_{32})$ $R = .72$ $s = 9.00$

4. $Y = 77.25 - .0765\ (\overline{BDT}_{31}) - .0255\ (BRT_{32}) + .0505\ (\overline{BDT}_{32})$

$R = .81$ $s = 7.89$

5. $Y = -0.42 + 57355\ (1/BTT_{31})$ $R = .72$ $s = 9.05$

For models 1, 2, and 5, the best times were found among all possible trials, even if errors had been made on some of those trials. The subjects in this study had been instructed to avoid errors. However, if the subjects had been led to believe that errors would not count against them, part 3 might have reverted to a pure reaction test, and any subsequent predictions would be highly suspect. An alternate model to (1), which incorporates the number of errors made on part 3 in the 10 trials (E), is

$$Y = 75.30 - .0252\ (BTT_{31}) + 1.437\ (E)$$

where

$$R = .75 \text{ and } s = 8.67$$

An alternate model to (5) using the number of errors E is

$$Y = -.348 + 1.874\ (E) + 57054\ (1/BTT_{31})$$

where

$$R = .73 \text{ and } s = 9.01$$

Similarly, for (2),

$$Y = 72.78 - .0206\ (\overline{BTT}_{31}) + 2.09\ (E)$$

where

$$R = .74 \text{ and } s = 8.87.$$

Surprisingly, including the errors results in positive coefficients for the E variable. This seems (erroneously) to imply that the more errors there are, the faster the predicted typing speed will be. Note that this refers to errors made on the predictive tests, not to errors made on the typing tests given at the end of the term. However, including the E variable does little to improve the prediction.

To account for errors made on the typing tests at the end of the semester, the net typing speed was found by subtracting the number of errors on the 5-minute tests from the number of words per minute. In applying similar statistical techniques to the net typing speed, there were few changes in the results.

The best models for predicting the net typing speed, with their summary statistics, are listed below (Y = net typing speed).

1. $Y = -12.83 + .246\ (E) + 65915\ (1/BTT_{31})$

   where $R = .71$ and $s = 10.7$

2. $Y = 76.81 - .237\ (E) - .0283\ (BTT_{31})$

   where $R = .72$ and $s = 10.7$

The correlation coefficients are of similar magnitude, but the larger standard errors indicate that there would be less precision in the predicted net typing speeds.

Finally, the effects that previous typing experience may have had on the results were examined. The 34 subjects were divided into two groups: those with previous typing experience and those without previous typing experience. The means of the two groups were then compared to identify any possible trends. The results are given in Table 9.

The results here are very similar to the comparison of the means when the two groups were formed by the subjects' typing speeds. Conclusions from this would be that previous typing experience does impact typing speed at the end of a one-semester typing course and that the predictor variables here are related to that past experience.

Conclusions

The results indicate that a test given to a beginning typing student is a good predictor of the typing speed that will be achieved by that student after a one-semester typing course. Specifically, three tests were given to students entering a beginning typing course. The test results were compared with gross typing speed attained by the students upon completion of the course. Although all three tests had predictive validity, the test requiring the student to enter a three-character sequence on a keyboard was far superior to the other two. The results of this test correlated well ($r = .75$)* with the gross typing speed. This correlation coefficient compares favorably with those obtained from Flanagan's tapping test, which resulted in correlation coefficients of approximately 0.5.

---

*In regression equations involving only one independent variable, the sign of correlation coefficient r is the same as the sign of the coefficient of that independent variable in the equation. For multiple regression equations where several independent variables may be used, the R value is given as positive. For comparisons of different models, the positive correlation coefficient will be used.

Table 9

Means of Predictive Variables for Experienced vs. Nonexperienced Subjects

Variable	Means		
	Experienced ($\underline{N}$ = 20)		Nonexperienced ($\underline{N}$ = 14)
BRT_1	238.60	>	204.93
$\overline{BRT}_1$	264.50	>	242.93
BTT_{21}	2076.50	<	2225.90
BRT_{21}	495.35	>	475.36
BDT_{21}	1448.20	<	1471.10
$\overline{BTT}_{21}$	2204.90	<	2370.60
$\overline{BRT}_{21}$	574.50	<	600.21
$\overline{BDT}_{21}$	1526.10	<	1628.60
BTT_{22}	2094.50	<	2265.00
BRT_{22}	509.50	<	544.21
BDT_{22}	1453.60	<	1507.40
$\overline{BTT}_{22}$	2226.80	<	2396.10
$\overline{BRT}_{22}$	590.05	<	633.00
$\overline{BDT}_{22}$	1537.40	<	1652.60
BTT_{31}	1533.10	<	1807.90
BRT_{31}	916.90	<	1001.20
BDT_{31}	460.30	<	634.57
$\overline{BTT}_{31}$	1785.90	<	2172.10
$\overline{BRT}_{31}$	1067.40	<	1177.90
$\overline{BDT}_{31}$	608.90	<	831.57
BTT_{32}	1534.90	<	1851.30
BRT_{32}	924.00	<	1031.20
BDT_{32}	465.05	<	653.71
$\overline{BTT}_{32}$	1832.10	<	2282.60
$\overline{BRT}_{32}$	1110.40	<	1245.40
$\overline{BDT}_{32}$	633.95	<	892.71
Typing speed	40.86	>	29.85

Based on the above, it was concluded that some variation on the three-character test may be useful in screening typist trainees. This test was implemented with a microcomputer, the keyboard being used for character entry. A program was written to time the subjects' responses and to record data.

It may be possible to improve the testing procedure by modifying or replacing the computing equipment. Some possible improvements are listed below.

1. Replace the computer keyboard with a simple eight-key keyboard, the keys being numbered one through eight. The subject would place his or her fingers over the keys as with a typewriter, then type in three-number (or n-number) sequences that would be provided by the computer display. This type of test would be more like the Flanagan tapping test and would not favor experienced typists as much as those using a standard keyboard.

2. Use an eight-key keyboard as above, but design and construct electronics to make the device self-contained, not requiring an external computer. This would require a built-in timer, random number generator, and display circuit. Random three-digit numbers would appear on an LED 9light-emitting diode) display, and the subject would type in the digits on the eight-key keyboard. Timed results would be automatically stored.

3. A simpler and less expensive implementation than the above would be the use of a programmable calculator to display the random numbers. The subject would then key in the numbers on the calculator keyboard. The calculator would be programed as a timer, and would store the timing results automatically in its registers. It is believed that programmable calculators costing less than $200 could be used for this purpose. The disadvantage of this approach is that the calculator keyboard is not very much like the typewriter keyboard, and eye-hand coordination may play too great a role in the task.

4. A still simpler implementation than the above would be to use a typewriter for the test. This may involve nothing more than a typing pretest (these are available commercially). Such a test should give a good measure of the student's experience, and if typing speed at the end of the course is highly dependent on the student's previous experience (as our data suggest), then the student's final typing speed should be well correlated with the results of the pretest.

Such a test, however, will not detect any other mechanisms that affect the student's progress. It therefore may be necessary to include additional tests to measure these other factors. Perhaps a typing test augmented by some form of the three-character test would have improved predictive validity over the typing test alone or the three-character test alone.

It seems clear that further research is required to further develop and refine our predictive tests. Although we have shown that prediction of success at typing can be accomplished with acceptable precision, the experimental technique used is not suitable for mass screening of typist trainees. In further research we would seek to

1. Simplify the data-gathering technique. The goal would be to minimize the time required by the subject, the time required by the person gathering the data, and the time required to analyze the data.

2. Simplify the data-taking equipment, eliminating or simplifying the computing equipment.

3. Improve the predictive validity of the tests. This may involve including tests using typewriters.

APPENDIX A

MACHINE LANGUAGE SUBROUTINE TO MEASURE TIME BETWEEN KEYSTROKES

```
$300LLLLL

0300-  A9 00     LDA  #$00
0302-  8D 10 C0  STA  $C010
0305-  A9 7F     LDA  #$7F
0307-  CD 00 C0  CMP  $C000
030A-  10 FB     BPL  $0307
030C-  A9 00     LDA  #$00
030E-  8D 10 C0  STA  $C010
0311-  20 50 03  JSR  $0350
0314-  60        RTS
0315-  EA        NOP
0316-  EA        NOP
0317-  EA        NOP
0318-  EA        NOP
0319-  EA        NOP
031A-  EA        NOP
031B-  EA        NOP
031C-  EA        NOP
031D-  EA        NOP
031E-  EA        NOP
031F-  EA        NOP
0320-  A9 00     LDA  #$00
0322-  8D 10 C0  STA  $C010
0325-  A9 7F     LDA  #$7F
0327-  CD 00 C0  CMP  $C000
032A-  10 FB     BPL  $0327
032C-  A9 00     LDA  #$00
032E-  8D 10 C0  STA  $C010
0331-  C6 00     DEC  $00
0333-  F0 06     BEQ  $033B
0335-  20 50 03  JSR  $0350
0338-  4C 31 03  JMP  $0331
033B-  60        RTS
033C-  EA        NOP
033D-  EA        NOP
033E-  EA        NOP
033F-  EA        NOP
0340-  EA        NOP
0341-  EA        NOP
0342-  EA        NOP
0343-  EA        NOP
0344-  EA        NOP
0345-  EA        NOP
0346-  EA        NOP
0347-  EA        NOP
0348-  EA        NOP
0349-  EA        NOP
034A-  EA        NOP
034B-  EA        NOP
034C-  EA        NOP
034D-  EA        NOP
034E-  EA        NOP
034F-  EA        NOP
0350-  20 70 03  JSR  $0370
0353-  A9 7F     LDA  #$7F
0355-  CD 00 C0  CMP  $C000
0358-  10 F6     BPL  $0350
035A-  A9 00     LDA  #$00
035C-  8D 10 C0  STA  $C010
035F-  60        RTS
0360-  EA        NOP
0361-  EA        NOP
0362-  EA        NOP
0363-  EA        NOP
0364-  EA        NOP
0365-  EA        NOP
0366-  EA        NOP
0367-  EA        NOP
0368-  EA        NOP
0369-  EA        NOP
036A-  EA        NOP
036B-  EA        NOP
036C-  EA        NOP
036D-  EA        NOP
036E-  EA        NOP
036F-  EA        NOP
0370-  E6 01     INC  $01
0372-  D0 10     BNE  $0384
0374-  E6 02     INC  $02
0376-  D0 10     BNE  $0388
0378-  E6 03     INC  $03
037A-  D0 10     BNE  $038C
037C-  E6 04     INC  $04
037E-  D0 10     BNE  $0390
0380-  20 2D FF  JSR  $FF2D
0383-  60        RTS
0384-  EA        NOP
0385-  EA        NOP
0386-  D0 00     BNE  $0388
0388-  EA        NOP
0389-  EA        NOP
038A-  D0 00     BNE  $038C
038C-  EA        NOP
038D-  EA        NOP
038E-  D0 00     BNE  $0390
0390-  60        RTS
0391-  EA        NOP
0392-  EA        NOP
0393-  EA        NOP
0394-  EA        NOP
0395-  EA        NOP
*
```

APPENDIX B

DOUBLE-TAP AND COUNTER PROGRAM

```
]
*0

]LIST

80  HOME
90  DIM T(30)
100 D$ =  CHR$ (4): REM  CTRL-D
200  PRINT : PRINT "WHAT IS THE T
     APFILE NAME";
210  INPUT A$
220  PRINT "WHAT IS THE REPEATFIL
     E NAME";
230  INPUT B$
240  PRINT D$;"OPEN ";A$
250  PRINT D$;"CLOSE ";A$
260  PRINT D$;"OPEN ";B$
270  PRINT D$;"CLOSE ";B$
300  PRINT "WHAT KEY DO YOU WANT
     THE SUBJECTS TO"
310  PRINT "STRIKE";
320  INPUT C$
330  IF  LEN (C$) <  > 1 THEN 320

400  HOME
500  PRINT "PLEASE TYPE IN YOUR F
     ULL NAME"
505  PRINT "THEN HIT THE 'RETURN'
      KEY."
510  INPUT NAME$
520  PRINT
600  PRINT "WHEN THE WORD 'READY'
      APPEARS,"
610  PRINT "TAP THE '";C$;"' KEY
     TWICE."
622  PRINT : PRINT "THE TWO TAPS
     SHOULD BE AS FAST AS"
624  PRINT "POSSIBLE, BUT YOU MAY
      PAUSE AS LONG AS"
626  PRINT "YOU WISH AFTER THE WO
     RD 'READY' APPEARS."
630  PRINT "BEFORE THE TEST START
     S YOU WILL BE"
640  PRINT "GIVEN A SHORT PRACTIC
     E SESSION."
650  PRINT : PRINT "HIT THE 'RETU
     RN' KEY TO START"
660  PRINT "THE PRACTICE SESSION.
     "
670  INPUT IN$
680  PRINT
700  FOR J = 1 TO 3000: NEXT
800  FOR I = 1 TO 10
810  GOSUB 5000
820  PRINT "READY"
830  CALL 768
840 T(I) = .04899 * ( PEEK (1) +
     256 * ( PEEK (2) + 256 * ( PEEK
     (3) + 256 *  PEEK (4))))
850  PRINT T(I)
860  FOR J = 1 TO 500: NEXT
870  NEXT I
900  PRINT : PRINT "THAT CONCLUDE
     S THE PRACTICE SESSION."
910  PRINT "HIT THE 'RETURN' KEY
     TO BEGIN THE TEST."
920  INPUT IN$
930  FOR J = 1 TO 3000: NEXT
1000  FOR I = 1 TO 30
1010  GOSUB 5000
1020  PRINT "READY"
1030  CALL 768
1040 T(I) = .04899 * ( PEEK (1) +
     256 * ( PEEK (2) + 256 * ( PEEK
     (3) + 256 *  PEEK (4))))
1050  PRINT T(I): REM  IN MS (UP
     TO 2.1X10↑5 SECS)
1060  FOR J = 1 TO 500: NEXT
1070  NEXT I
1100  PRINT : PRINT "THAT CONCLUD
     ES TEST #1"
1110  GOSUB 6000
1500  PRINT : PRINT "IN TEST #2 Y
     OU WILL TAP THE '";C$;"' KEY
     "
1510  PRINT "REPEATEDLY."
1520  PRINT
1530  PRINT "BEFORE THE TEST BEGI
     NS YOU WILL BE"
1540  PRINT "GIVEN A SHORT PRACTI
     CE SESSION."
1545  PRINT
1560  PRINT "WHEN THE WORD 'READY
     ' APPEARS,"
1570  PRINT "TAP THE '";C$;"' KEY
      AS FAST AS YOU CAN"
1580  PRINT "WITH ONE FINGER UNTI
     L THE WORD 'STOP'"
1590  PRINT "APPEARS."
1600  PRINT
1610  PRINT "HIT 'RETURN' WHEN YO
     U ARE READY TO"
1620  PRINT "START THE PRACTICE S
     ESSION."
1630  INPUT IN$
1640  PRINT
1650  FOR J = 1 TO 3000: NEXT
1800  GOSUB 5000
1810  POKE 0,15
2000  PRINT "READY"
2010  CALL 800
2020 T50 = .04899 * ( PEEK (1) +
     256 * ( PEEK (2) + 256 * ( PEEK
     (3) + 256 *  PEEK (4))))
2025  PRINT T50
```

```
2030  PRINT "STOP"
2100  PRINT : CALL  - 198
2110  PRINT "THAT CONCLUDES THE P
RACTICE SESSION."
2115  PRINT
2120  PRINT "HIT 'RETURN' WHEN YO
U ARE READY TO"
2130  PRINT "START THE TEST."
2140  INPUT IN$
2150  PRINT
2160  FOR J = 1 TO 3000: NEXT
2800  GOSUB 5000
3000  PRINT "READY"
3010  CALL 800
3020 T50 = .04899 * ( PEEK (1) +
256 * ( PEEK (2) + 256 * ( PEEK
(3) + 256 *  PEEK (4))))
3025  PRINT T50
3030  PRINT "STOP"
3035  CALL  - 198
3040  GOSUB 7000
3100  PRINT : PRINT "THANKS FOR H
ELPING US OUT."
3200  INPUT IN$
3210  IF  LEN ( IN$ ) < 1 THEN 3200

3220  IF IN$ = "END" THEN 4000
3230  IF IN$ = "NEXT" THEN 400
3240  GOTO 3200
4000  PRINT D$;"LOCK ";A$
4010  PRINT D$;"LOCK ";B$
4020  END
5000  POKE 0,50
5010  POKE 1,0
5020  POKE 2,0
5030  POKE 3,0
5040  POKE 4,0
5050  RETURN
6000  PRINT D$;"APPEND ";A$
6010  PRINT D$;"WRITE ";A$
6020  PRINT NAME$
6030  FOR I = 1 TO 30
6040  PRINT T(I)
6050  NEXT I
6060  PRINT D$;"CLOSE ";A$
6080  RETURN
7000  PRINT
7005  PRINT D$;"APPEND ";B$
7010  PRINT D$;"WRITE ";B$
7020  PRINT NAME$
7030  PRINT T50
7040  PRINT D$;"CLOSE ";B$
7050  RETURN
```

APPENDIX C

TYPING EXPERIENCE QUESTIONNAIRE AND CONSENT FORM

Name_____ Date_____

Are you right- or left-handed?_____

Describe any formal typing training you have had: _____

_____

Which typing method do you use, e.g., the "hunt and peck" method, the "touch method" (typing without looking at your fingers)?_____

_____

Describe any typing experience you have had in your work: _____

_____

_____

What is your gross typing speed in words per minute (if known)?_____

List all musical instruments which you play and rate your ability from 1 (poor) to 10 (virtuoso). _____

_____

_____

We are attempting to gather data on digital dexterity as it relates to success at typing. To do this, we wish to measure your response to certain simple tests of dexterity. They may include such tasks as tapping a key or typing a few characters on a keyboard. The records of your results along with the results of your typing course will be kept confidential and will be published only as statistics.

Please sign your name in the space provided if you understand the above and agree to allow the measurements to be made, and agree to allow your grades and typing scores to be made available to other experimenters.

_____
Signature

APPENDIX D

DIGITAL DEXTERITY TEST FORM

Name_____ Date _____

Stopwatch tapping test: Record time to turn stopwatch on and off in 100ths of seconds.

1_____	11_____	21_____
2_____	12_____	22_____
3_____	13_____	23_____
4_____	14_____	24_____
5_____	15_____	25_____
6_____	16_____	26_____
7_____	17_____	27_____
8_____	18_____	28_____
9_____	19_____	29_____
10_____	20_____	30_____

Mechanical counter test: Record time to advance counter from 0 to 50.

_____ seconds.

APPENDIX E

SAMPLE RUN OF DOUBLE-TAP AND COUNTER PROGRAM

```
]RUN

WHAT IS THE TAPFILE NAME?TAPFILETEST
WHAT IS THE REPEATFILE NAME?REPEATFILETEST
WHAT KEY DO YOU WANT THE SUBJECTS TO
STRIKE?B
PLEASE TYPE IN YOUR FULL NAME
THEN HIT THE 'RETURN' KEY.
?THOMAS G. CLEAVER

WHEN THE WORD 'READY' APPEARS,
TAP THE 'B' KEY TWICE.

THE TWO TAPS SHOULD BE AS FAST AS
POSSIBLE, BUT YOU MAY PAUSE AS LONG AS
YOU WISH AFTER THE WORD 'READY' APPEARS.
BEFORE THE TEST STARTS YOU WILL BE
GIVEN A SHORT PRACTICE SESSION.

HIT THE 'RETURN' KEY TO START
THE PRACTICE SESSION.
?

READY
493.7788
READY
174.4044
READY
137.172
READY
131.2932
READY
123.4548
READY
141.0912
READY
152.8488
READY
115.6164
READY
166.566
READY
148.9296

THAT CONCLUDES THE PRACTICE SESSION.
HIT THE 'RETURN' KEY TO BEGIN THE TEST.
?
READY
127.374
READY
137.172
READY
166.566
READY
105.8184
READY
111.6972
READY
115.6164
READY
127.374
READY
133.2528
READY
123.4548
READY
137.172
READY
131.2932
READY
127.374
READY
121.4952
READY
143.0508
READY
123.4548
READY
131.2932
READY
125.4144
READY
250.8288
READY
129.3336
READY
139.1316
READY
139.1316
READY
160.6872
READY
129.3336
READY
121.4952
READY
143.0508
READY
125.4144
READY
113.6568
READY
146.97
READY
109.7376
READY
119.3356

THAT CONCLUDES TEST #1

IN TEST #2 YOU WILL TAP THE 'B' KEY
REPEATEDLY.

BEFORE THE TEST BEGINS YOU WILL BE
GIVEN A SHORT PRACTICE SESSION.

WHEN THE WORD 'READY' APPEARS,
TAP THE 'B' KEY AS FAST AS YOU CAN
WITH ONE FINGER UNTIL THE WORD 'STOP'
```

```
APPEARS.

HIT 'RETURN' WHEN YOU ARE READY TO
START THE PRACTICE SESSION.
?

READY
1939.40404
STOP

THAT CONCLUDES THE PRACTICE SESSION.

HIT 'RETURN' WHEN YOU ARE READY TO
START THE TEST.
?B

READY
7485.03513
STOP


THANKS FOR HELPING US OUT.
?BEND

]PR#0
*
```

APPENDIX F

MACHINE LANGUAGE SUBROUTINE TO TIME SUBJECTS' RESPONSES

```
*300LLLL

0300-  8D 10 C0    STA   $C010
0303-  20 20 03    JSR   $0320
0306-  A9 7F       LDA   #$7F
0308-  CD 00 C0    CMP   $C000
030B-  10 F6       BPL   $0303
030D-  AD 00 C0    LDA   $C000
0310-  8D 10 C0    STA   $C010
0313-  60          RTS
0314-  EA          NOP
0315-  EA          NOP
0316-  EA          NOP
0317-  EA          NOP
0318-  EA          NOP
0319-  EA          NOP
031A-  EA          NOP
031B-  EA          NOP
031C-  EA          NOP
031D-  EA          NOP
031E-  EA          NOP
031F-  EA          NOP
0320-  E6 01       INC   $01
0322-  D0 10       BNE   $0334
0324-  E6 02       INC   $02
0326-  D0 10       BNE   $0338
0328-  E6 03       INC   $03
032A-  D0 10       BNE   $033C
032C-  E6 04       INC   $04
032E-  D0 10       BNE   $0340
0330-  20 2D FF    JSR   $FF2D
0333-  60          RTS
0334-  EA          NOP
0335-  EA          NOP
0336-  D0 00       BNE   $0338
0338-  EA          NOP
0339-  EA          NOP
033A-  D0 00       BNE   $033C
033C-  EA          NOP
033D-  EA          NOP
033E-  D0 00       BNE   $0340
0340-  60          RTS
0341-  EA          NOP
0342-  EA          NOP
0343-  EA          NOP
0344-  EA          NOP
0345-  EA          NOP
0346-  EA          NOP
0347-  EA          NOP
0348-  EA          NOP
0349-  EA          NOP
034A-  EA          NOP
034B-  EA          NOP
034C-  EA          NOP
034D-  EA          NOP
034E-  EA          NOP
034F-  EA          NOP
0350-  A2 00       LDX   #$00
0352-  20 00 03    JSR   $0300
0355-  9D 00 02    STA   $0200,X
0358-  20 ED FD    JSR   $FDED
035B-  A5 01       LDA   $01
035D-  85 05       STA   $05
035F-  A5 02       LDA   $02
0361-  85 06       STA   $06
0363-  A5 03       LDA   $03
0365-  85 07       STA   $07
0367-  A5 04       LDA   $04
0369-  85 08       STA   $08
036B-  E8          INX
036C-  20 03 03    JSR   $0303
036F-  9D 00 02    STA   $0200,X
0372-  20 ED FD    JSR   $FDED
0375-  E8          INX
0376-  8A          TXA
0377-  C5 00       CMP   $00
0379-  D0 F1       BNE   $036C
037B-  60          RTS
037C-  EA          NOP
037D-  EA          NOP
037E-  EA          NOP
037F-  EA          NOP
#0

]
```

APPENDIX G

REACTION TIME, INDIVIDUAL FINGER DEXTERITY, AND
THREE-CHARACTER INPUT PROGRAM

```
LIST\
]LIST

500  POKE 928,169: POKE 929,0: POKE
     930,76: POKE 931,237: POKE 9
     32,253: REM  FIX DOS APPEND
     BUG
1000  REM  INTIALIZATION
1010  HOME
1020 D$ =  CHR$ (4): REM  CTRL-D
1100  DIM R(25,10): REM  REACTION
      TIME, R(# OF SUBJECTS, NUMB
     ER OF MEASUREMENTS PER SUBJE
     CT)
1110  DIM F(25,10,2,1): REM  FING
     ER DEXTERITY, F(# OF SUBJECT
     S, #OF MEASUREMENTS PER SUBJ
     ECT, (0=ERRORS, 1=RESPONSE T
     IME, 2=TIME BETWEEN START AN
     D LAST CHARACTER), (0=RIGHT,
      1=LEFT))
1120  DIM C(25,20,2): REM CHARACT
     ER INPUT TIME, C(#OF SUBJECT
     S, # OF MEASUREMENTS PER SUB
     JECT, (0=ERRORS, 1=RESPONSE
     TIME, 2=TIME BETWEEN START A
     ND LAST CHARACTER))
1130  DIM NAME$(25)
1140  DIM SEX$(25)
1150  DIM XP$(25)
1160  DIM FI$(1),IN$(1)
1200  REM  TIMER FORMULA
1210  DEF  FN TIME(I) = .04899 *
     ( PEEK (1) + 256 * ( PEEK (2
     ) + 256 * ( PEEK (3) + 256 *
     ( PEEK (4)))))
1220  DEF  FN TTIME(I) = .04899 *
     ( PEEK (5) + 256 * ( PEEK (6
     ) + 256 * ( PEEK (7) + 256 *
     ( PEEK (8)))))
1300  PRINT : PRINT "WHAT IS THE
     FILE NAME";
1310  INPUT FI$
1320  PRINT D$;"OPEN  ";FI$
1330  PRINT D$;"CLOSE ";FI$
2000  REM  INTRODUCTION
2010 I = 0
2100  HOME
2110  PRINT
2120 I = I + 1
2125  IF I > 25 THEN  PRINT "NO M
     ORE SUBJECTS CAN BE ENTERED
     ONTO    THIS FILE." GOTO 802
     0
2130  PRINT "PLEASE TYPE YOUR FUL
     L NAME,"
2135  PRINT : PRINT "THEN HIT 'RE
     TURN'";
2140  INPUT NAME$(I)
2150  PRINT
2155  IF  LEN (NAME$(I)) < 5 THEN
     2130
2160  PRINT "ARE YOU MALE OR FEMA
     LE (M/F)?  ";
2170  GET SEX$(I)
2180  PRINT SEX$(I)
2190  IF SEX$(I) <  > "M" AND SEX
     $(I) <  > "F" THEN 2150
2200  PRINT
2210  PRINT "HAVE YOU HAD ANY PRE
     VIOUS TYPING"
2215  PRINT : PRINT "TRAINING OR
     EXPERIENCE (Y/N)?  ";
2220  GET XP$(I)
2230  PRINT XP$(I)
2240  IF XP$(I) <  > "Y" AND XP$(
     I) <  > "N" THEN 2200
3000  REM  TEST 1
3010  HOME
3020  PRINT
3030  PRINT  TAB( 10);"REACTION T
     IME TEST"
3040  PRINT
3050  GOSUB 15000: REM  DELAY
3060  PRINT "WHEN 'GO!' APPEARS O
     N THE SCREEN,"
3065  PRINT : PRINT "STRIKE THE S
     PACE BAR AS QUICKLY AS"
3067  PRINT : PRINT "YOU CAN."
3069  GOSUB 15000
3070  GOSUB 3500
3080  PRINT : PRINT "OK, NOW TRY
     IT AGAIN."
3085  GOSUB 15000
3090  GOSUB 3500
3100  HOME
3110  PRINT
3120  PRINT "THAT WAS PRACTICE."
3130  PRINT
3140  PRINT "NOW YOU WILL DO THE
     REAL THING 10 TIMES."
3160  GOSUB 15000: REM  DELAY
3170  FOR J = 1 TO 10
3180  GOSUB 3500
3190 R(I,J) = T
3200  NEXT J
3210  PRINT
3220  PRINT "THAT COMPLETES THE R
     EACTION TIME TEST."
3230  GOSUB 15000: REM  DELAY
3240  GOTO 4000
3500  REM  REACTION TIME SUBROUTI
     NE
3510  PRINT : PRINT "GET READY...
     "
```

```
3515  GOSUB 16000: REM  RANDOM DE
    LAY
3517  GOSUB 12000: REM  ZERO REGI
    STERS
3520  PRINT : PRINT  TAB( 18);
3525  PRINT "GO!": CALL 768
3530  HOME
3540  CALL  - 198: REM  SOUND BEL
    L
3550  PRINT
3560 T =  FN TIME(I)
3570  PRINT T
3580  GOSUB 15000: REM  DELAY
3599  RETURN
4000  REM  TEST 2
4010  HOME
4020  PRINT
4030  PRINT  TAB( 10);"FINGER DEX
    TERITY TEST"
4040  PRINT
4050  GOSUB 15000: REM  DELAY
4060  PRINT "POSITION YOUR FINGER
    S OVER THE KEYS"
4065  PRINT : PRINT "AS SHOWN."
4070  PRINT
4080  PRINT  TAB( 10);"A S D F G
    H J K L ;"
4085  PRINT
4090  PRINT  TAB( 10);"L R M I
      I M R L"
4100  PRINT  TAB( 10);"I I I N
      N I I I"
4110  PRINT  TAB( 10);"T N D D
      D D N T"
4120  PRINT  TAB( 10);"T G D E
      E D G T"
4130  PRINT  TAB( 10);"L   L X
      X L   L"
4140  PRINT  TAB( 10);"E F E
        E F E"
4150  PRINT  TAB( 10);"  I   F
      F   I"
4160  PRINT  TAB( 10);"F N F I
      I F N I"
4170  PRINT  TAB( 10);"I G I N
      N I G I"
4180  PRINT  TAB( 10);"N E N G
      G N E N"
4190  PRINT  TAB( 10);"G R G E
      E G R G"
4200  PRINT  TAB( 10);"E   E R
      R E   E"
4210  PRINT  TAB( 10);"R   R
        R   R"
4220  GOSUB 15000: REM  DELAY
4230  GOSUB 15000
4240  GOSUB 15000
4250  PRINT : PRINT "HOLDING YOUR
    FINGERS IN THIS POSITION"
4260  PRINT
4270  PRINT "TYPE:      ASDFJKL;"
4280  PRINT
4290  GOSUB 12000: REM  RESET REG
    ISTERS
4300  POKE 0,8
4310  CALL 848
4320  GOSUB 13000: REM  LOAD IN$
4330  IF IN$ = "ASDFJKL;" THEN 43
    50
4340  GOSUB 20000: REM   RASBERRY

4345  PRINT "  NO, THAT'S WRONG.
    TRY AGAIN.": GOTO 4260
4350  PRINT "  CORRECT"
4355  CALL  - 198: REM   SOUND BE
    LL
4360  GOSUB 15000: PRINT : PRINT
    "STILL HOLDING YOUR FINGERS
    IN THIS"
4365  PRINT : PRINT "POSITION TYP
    E:  ;LKJFDSA"
4370  GOSUB 12000: POKE 0,8: CALL
    848
4375  GOSUB 13000: REM  LOAD IN$

4380  IF IN$ = ";LKJFDSA" THEN 44
    00
4390  GOSUB 20000: REM  RASBERRY
4395  PRINT "  NO, THAT'S WRONG.
    TRY AGAIN.": GOTO 4360
4400  PRINT "  CORRECT"
4405  CALL  - 198: REM SOND BELL
4410  GOSUB 15000
4420  HOME : PRINT : PRINT "EACH
    TIME 'LEFT' APPEARS ON THE S
    CREEN  "
4425  PRINT "YOU SHOULD TYPE 'ASD
    FJKL;' AND EACH TIME"
4430  PRINT "'RIGHT' APPEARS YOU
    SHOULD TYPE          "
4435  PRINT "';LKJFDSA'.  GO AS F
    AST AS YOU CAN       "
4440  PRINT "WITHOUT MAKING MISTA
    KES."
4441  GOSUB 15000
4442  GOSUB 15000: REM   DELAY
4443  GOSUB 15000
4444  GOSUB 15000
4445 K = 0: GOSUB 4500
4450  IF E = 1 THEN  PRINT : PRINT
    "TRY AGAIN.": GOTO 4445
4455 K = 1: GOSUB 4500
4460  IF E = 1 THEN  PRINT : PRINT
    "TRY AGAIN.": GOTO 4455
4465  PRINT : PRINT "THAT WAS PRA
    CTICE."
4470  PRINT : PRINT "NOW FOR THE
    REAL THING.  REMEMBER, GO AS
    "
4472  PRINT "FAST AS YOU CAN WITH
```

```
    OUT MAKING MISTAKES."
4473  GOSUB 15000: REM   DELAY
4474 K0 = 0:K1 = 0
4475  FOR J = 0 TO 19
4477  IF (10 - K0) / (20 - J) >  RND
    (1) THEN K = 0:K0 = K0 + 1: GOTO
    4480
4478 K = 1:K1 = K1 + 1
4480  GOSUB 4500
4482 T1 =  FN TTIME(I)
4484  IF K = 0 THEN F(I,K0,0,0) =
    E:F(I,K0,1,0) = T1:F(I,K0,2,
    0) = T: GOTO 4490
4486 F(I,K1,0,1) = E:F(I,K1,1,1) =
    T1:F(I,K1,2,1) = T
4490  NEXT J
4495  PRINT : PRINT "THAT COMPLET
    ES THE FINGER DEXTERITY TEST
    "
4497  GOSUB 15000
4498  GOTO 5000
4500  REM  FINGER DEXTERITY INPUT
     SUBROUTINE
4505 E = 0
4510  PRINT : PRINT "GET READY...
    "
4515  GOSUB 16000: REM  RANDOM DE
    LAY
4517  POKE 0,8: GOSUB 12000: REM
     RESET REGISTERS
4520  PRINT : PRINT  TAB( 18);
4530  IF K = 0 THEN 4700: REM  RI
    GHT
4540  PRINT "LEFT": CALL 848
4545  GOSUB 13000: REM  LOAD IN$

4550  IF IN$ = "ASDFJKL;" THEN 46
    00
4560  PRINT "  WRONG":E = 1
4570  GOSUB 20000: REM  RASBERRY
4580  GOTO 4900
4600  PRINT "  CORRECT"
4610  CALL  - 198: REM  SOUND BEL
    L
4620  GOTO 4900
4700  PRINT "RIGHT": CALL 848
4710  GOSUB 13000: REM  LOAD IN$
4720  IF IN$ = ";LKJFDSA" THEN 46
    00
4730  GOTO 4560
4900  PRINT
4910 T =  FN TIME(I)
4920  PRINT T
4930  GOSUB 15000: REM  DELAY
4940  HOME
4999  RETURN
5000  REM  TEST 3
5010  HOME
5020  PRINT : PRINT  TAB( 10);"LE
    TTER RECOGNITION TEST"
5030  GOSUB 15000
5040  PRINT : PRINT "KEEP YOUR FI
    NGERS ON 'ASDF' AND 'JKL;'
    "
5050  PRINT "JUST AS IN THE LAST
    TEST."
5060  GOSUB 15000
5065  PRINT
5070  PRINT "TYPE:  DKA"
5080  POKE 0,3: GOSUB 12000
5090  CALL 848
5095  GOSUB 14000
5100  IF IN$ = "DKA" THEN 5150
5110  GOSUB 20000: REM  RASBERRY

5120  PRINT "  NO, THAT'S WRONG.
     TRY AGAIN.": GOTO 5060
5150  PRINT "  CORRECT"
5160  CALL  - 198: REM SOUND BELL

5170  GOSUB 15000
5180  HOME
5190  PRINT : PRINT "NOW TYPE:  F
    ;S"
5200  POKE 0,3: GOSUB 12000
5210  CALL 848
5215  GOSUB 14000
5220  IF IN$ = "F;S" THEN 5250
5230  GOSUB 20000: REM  RASBERRY

5240  PRINT "  NO, THAT'S WRONG.
     TRY AGAIN.": GOTO 5190
5250  PRINT "  CORRECT"
5260  CALL  - 198: REM  SOUND BEL
    L
5270  GOSUB 15000
5280  PRINT : PRINT "THAT WAS PRA
    CTICE."
5290  PRINT : PRINT "NOW FOR THE
    REAL THING."
5300  GOSUB 15000
5310  PRINT : PRINT "TYPE WHAT AP
    PEARS ON THE SCREEN."
5320  PRINT : PRINT "BE SURE TO H
    OLD YOUR FINGERS IN THE"
5325  PRINT
5330  PRINT "PROPER POSITION."
5340  GOSUB 15000
5350  GOSUB 15000
5355  GOSUB 25000: REM  SETUP ARR
    AY
5360  FOR J = 1 TO 10
5370  GOSUB 5500
5380 T1 =  FN TTIME(I)
5390 C(I,J,0) = E:C(I,J,1) = T1:C
    (I,J,2) = T
5400  NEXT J
5410  PRINT : PRINT "THAT COMPLET
    ES THE TESTS."
5420  PRINT : PRINT "THANKS FOR H
```

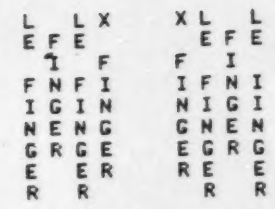
```
    ELPING US OUT."
5430  GOTO 6000
5500  REM  CHARACTER RECOGNITION
    INPUT
5510 E = 0
5520  PRINT : PRINT "GET READY...
    "
5530  GOSUB 16000: REM   RANDOM D
    ELAY
5540  POKE 0,3: GOSUB 12000: REM
     RESET REGISTERS
5550  PRINT : PRINT  TAB( 19);
5560  GOSUB 25200: REM  SELECT B$

5570  PRINT B$: CALL 848
5580  GOSUB 14000: REM LOAD IN$
5590  IF IN$ = B$ THEN 5700
5600  PRINT "  WRONG":E = 1
5610  GOSUB 20000: REM   RASBERRY

5620  GOTO 5800
5700  PRINT "  CORRECT"
5710  CALL  - 198: REM SOUND BELL

5800  PRINT
5810 T =  FN TIME( I)
5820  PRINT T
5830  GOSUB 15000: REM   DELAY
5840  HOME
5999  RETURN
6000  REM  SAVE DATA ON DISK
6010  PRINT D$;"APPEND ";FI$
6020  PRINT D$;"WRITE  ";FI$
6030  GOSUB 8120
6300  CALL 928: PRINT
6310  PRINT D$;"CLOSE ";FI$
7000  REM  END TEST?
7010  INPUT IN$
7020  IF IN$ = "NEXT" THEN 2100
7030  IF IN$ = "END" THEN 8000
7040  GOTO 7000
8000  REM  FILE BACKUP
8010  HOME
8020  PRINT
8030  PRINT "REMOVE THE DISKETTE
    AND INSERT ANOTHER  "
8040  PRINT "ONE.  THIS WILL BE U
    SED FOR A BACKUP     "
8050  PRINT "FILE.  WHEN THE NEW
    DISK IS IN PLACE HIT"
8060  PRINT "'RETURN'."
8070  INPUT IN$
8090 N = I
8100  PRINT D$;"OPEN ";FI$;"/BACK
    UP"
8110  PRINT D$;"WRITE  ";FI$;"/BA
    CKUP"
8115  FOR I = 1 TO N
8117  GOSUB 8120
8118  GOTO 8500
8120  PRINT NAME$( I)
8130  PRINT SEX$( I)
8140  PRINT XP$( I)
8150  FOR J = 1 TO 10
8160  PRINT R( I,J)
8170  NEXT J
8180  FOR K = 0 TO 1
8190  FOR J = 1 TO 10
8200  PRINT F( I,J,0,K)
8210  PRINT F( I,J,1,K)
8220  PRINT F( I,J,2,K)
8230  NEXT J
8240  NEXT K
8250  FOR J = 1 TO 10
8260  PRINT C( I,J,0)
8270  PRINT C( I,J,1)
8280  PRINT C( I,J,2)
8290  NEXT J
8295  RETURN
8500  NEXT I
8510  PRINT D$;"CLOSE "
9999  END
12000  REM
12010  FOR DL = 1 TO 8
12020  POKE DL,0
12030  NEXT DL
12999  RETURN
13000  REM  LOAD IN$
13005 IN$ =  CHR$ ( PEEK (512) -
    128)
13010  FOR DL = 513 TO 519
13020 IN$ = IN$ +  CHR$ ( PEEK (D
    L) - 128)
13030  NEXT DL
13999  RETURN
14000  REM   LOAD IN$
14005 IN$ =  CHR$ ( PEEK (512) -
    128) +  CHR$ ( PEEK (513) -
    128) +  CHR$ ( PEEK (514) -
    128)
14999  RETURN
15000  REM  DELAY
15010  FOR DLY = 1 TO 2000
15020  NEXT DLY
15999  RETURN
16000  REM  RANDOM DELAY
16010 D1 = 2000
16020 D1 = D1 + 2000 *  RND (1)
16030  FOR DLY = 1 TO D1
16040  NEXT DLY
16999  RETURN
20000  REM
20002 RAS =  - 16336
20005  FOR DL = 1 TO 50
20010 RS =  PEEK (RAS) +  PEEK (R
    AS) +  PEEK (RAS) +  PEEK (R
    AS) +  PEEK (RAS)
20020  NEXT DL
20999  RETURN
25000  REM
```

```
25010 A$(1) = "AKF"
25020 A$(2) = "JA;"
25030 A$(3) = "SLA"
25040 A$(4) = "KSJ"
25050 A$(5) = "F;S"
25060 A$(6) = "JDL"
25070 A$(7) = "DJS"
25080 A$(8) = "LFK"
25090 A$(9) = "ALD"
25100 A$(10) = "LDK"
25199  RETURN
25200 DL =  INT (1 + 10 *  RND (1
     ))
25210  IF A$(DL) = "0" THEN 25200

25215 B$ = A$(DL)
25220 A$(DL) = "0"
25999  RETURN

]
```

APPENDIX H

SAMPLE RUN OF REACTION TIME, INDIVIDUAL FINGER DEXTERITY, AND THREE-CHARACTER INPUT PROGRAM

```
\
]RUN
WHAT IS THE FILE NAME?TEST
PLEASE TYPE YOUR FULL NAME,
THEN HIT 'RETURN'?THOMAS G. CLEAVER
ARE YOU MALE OR FEMALE (M/F)?  M
HAVE YOU HAD ANY PREVIOUS TYPING
TRAINING OR EXPERIENCE (Y/N)?  N
        REACTION TIME TEST
WHEN 'GO!' APPEARS ON THE SCREEN,
STRIKE THE SPACE BAR AS QUICKLY AS
YOU CAN.
GET READY...
                GO!
265.0359
OK, NOW TRY IT AGAIN.
GET READY...
                GO!
263.86014
THAT WAS PRACTICE.
NOW YOU WILL DO THE REAL THING 10 TIMES.
GET READY...
                GO!
181.99785
GET READY...
                GO!
210.36306
GET READY...
                GO!
241.96161
GET READY...
                GO!
204.7782
GET READY...
                GO!
271.50258
GET READY...
                GO!
280.85967
GET READY...
                GO!
171.17106
GET READY...
                GO!
255.7278
GET READY...
                GO!
206.34588
GET READY...
                GO!
167.25186
THAT COMPLETES THE REACTION TIME TEST.
        FINGER DEXTERITY TEST
POSITION YOUR FINGERS OVER THE KEYS
AS SHOWN.
        A S D F G H J K L ;

        L R M I     I M R L
        I I I N     N I I I
        T N D D     D D N T
        T G D E     E D G T
```



HOLDING YOUR FINGERS IN THIS POSITION

TYPE: ASDFJKL;

ASDFJKLL NO, THAT'S WRONG. TRY AGAIN.

TYPE: ASDFJKL;

ASDFJKL; CORRECT

STILL HOLDING YOUR FINGERS IN THIS

POSITION TYPE: ;LKJFDSA
;LKDSADF NO, THAT'S WRONG. TRY AGAIN.

STILL HOLDING YOUR FINGERS IN THIS

POSITION TYPE: ;LKJFDSA
;LKJFDSA CORRECT

EACH TIME 'LEFT' APPEARS ON THE SCREEN
YOU SHOULD TYPE 'ASDFJKL;' AND EACH TIME
'RIGHT' APPEARS YOU SHOULD TYPE
';LKJFDSA'. GO AS FAST AS YOU CAN
WITHOUT MAKING MISTAKES.

GET READY...

RIGHT
;LKJFDSA CORRECT

2910.88782

GET READY...

LEFT
ASDFJKL; CORRECT

1680.21003

THAT WAS PRACTICE.

NOW FOR THE REAL THING. REMEMBER, GO AS
FAST AS YOU CAN WITHOUT MAKING MISTAKES.

GET READY...

LEFT
ASDFJKL; CORRECT

1358.73765

GET READY...

RIGHT
;LLKJFDA WRONG

1785.88146

GET READY...

RIGHT
;LKJFDSA CORRECT

1971.06366

GET READY...

RIGHT
;LKJFDSA CORRECT

1457.35452

GET READY...

RIGHT
;LKJFDSA CORRECT

1741.05561

GET READY...

LEFT
ASDFJK;; WRONG

2447.63838

GET READY...

LEFT
ASDFJKL; CORRECT

1621.42203

GET READY...

LEFT
ASDFJKL; CORRECT

1152.7347

GET READY...

RIGHT
;LKJFDSA CORRECT

1491.94146

GET READY...

```
                    RIGHT
;LKJFDSA  CORRECT

1573.95072

GET READY...

                   LEFT
ASDFJKL;  CORRECT

1316.31231

GET READY...

                   RIGHT
;LKJFDSA  CORRECT

1712.73939

GET READY...

                   LEFT
ASDFJK;L  WRONG

1087.578

GET READY...

                   LEFT
ASDFJK;L  WRONG

1900.51806

GET READY...

                   LEFT
ASDFJKL;  CORRECT

1318.56585

GET READY...

                   LEFT.
ASDFKJL;  WRONG

1177.2297

GET READY...

                   RIGHT
;LLKJFDS  WRONG

1652.97159

GET READY...

                   LEFT
ASDFJKL;  CORRECT

1716.95253

GET READY...

                   RIGHT
;LKJFDSA  CORRECT

2002.2213

GET READY...

                   RIGHT
;LKJFDSA  CORRECT

2017.60416

THAT COMPLETES THE FINGER DEXTERITY TEST

        LETTER RECOGNITION TEST

KEEP YOUR FINGERS ON 'ASDF' AND 'JKL;'
JUST AS IN THE LAST TEST.

TYPE:  DKA
DKJ  NO, THAT'S WRONG.  TRY AGAIN.

TYPE:  DKA
DKA  CORRECT

NOW TYPE:  F;S
F;S  CORRECT

THAT WAS PRACTICE.

NOW FOR THE REAL THING.

TYPE WHAT APPEARS ON THE SCREEN.

BE SURE TO HOLD YOUR FINGERS IN THE

PROPER POSITION.

GET READY...

                   LFK
LFK  CORRECT

2848.13163

GET READY...

                   AKF
AKD  WRONG

2522.0052

GET READY...

                   F;S
F;S  CORRECT
```

```
2112.00789
GET READY...
                    JAJ
JAJ  CORRECT
2585.00634
GET READY...
                    KSJ
KSJ  CORRECT
2874.58623
GET READY...
                    ALD
ALD  CORRECT
3210.60864
GET READY...
                    LDK
LDK  CORRECT
2730.75159
GET READY...
                    SLA
SLA  CORRECT
2696.26263
GET READY...
                    JDL
JDL  CORRECT
2380.71804
GET READY...
                    DJS
SJD  WRONG
816.90825
THAT COMPLETES THE TESTS.
THANKS FOR HELPING US OUT.
TEND
REMOVE THE DISKETTE AND INSERT ANOTHER
ONE.  THIS WILL BE USED FOR A BACKUP
FILE.  WHEN THE NEW DISK IS IN PLACE HIT
'RETURN'.
```